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Freshwater Diatomflora of the Panhalgarh Hillfort in the Kolhapur district

by

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SYNOPSIS

This is an account on the freshwater Diatomflora of the Panhalgarh hills in the Kolhapur district based on collections and studies made during different seasons of the years 1953—56. Besides the taxonomical studies, it is also endeavoured here to present notes on ecology, occurrence and distribution of these diatoms. A suggestion also has been made, wherever possible, regarding their form-change occurring during their reproduction or otherwise under the influence of varying climatic conditions —.

INTRODUCTION

The author's main interest in describing the Diatomflora of Panhalgarh hills is firstly that this area never before has been explored. Secondly, the collections and studies that could be made from season to season for a continuous period of about three-and-half years tended to throw some light on periodicity, occurrence, distribution of the diatoms and on growth phases of certain of them. Thirdly, the material collected from the region was found to be fairly rich in species and thus it made a worthwhile study. Lastly, the hill-flora, leaving the cosmopolitan elements, appeared to be distinct from that of the plains.

Panhalgarh is an ancient hill-fort on one of the spurs of the Western Ghats. It was probably built during the times of great, noble Maratha king — Chhatrapati Shivaji who made it his favourite place of dwelling. During a later period when the Maratha kingdom was distintegrated — it came in possession of Mohammedan rulers —

and again it changed hands ultimately to remain in possession of descendants of the Maratha Dynasty untill lately. This hill-fort had a glorious history that dates back to 17th century A. D. It had a continuous high wall which has crumbled down and what remains today is in delapidated condition.

The hill-fort is situated at latitude 16° 50' N. and Longitude 75° 10' E., at about 12 miles west of Kolhapur, to which it is connected by a tarred higway.It has an elevation varying between 2850 to 3177 feet above sea-level. The average rainfall is more than 100 inches, because of the direct influence of the S.-West moisture laden monsoon winds from the Arabian Sea. About 90 % of the precipitation occurs from June to September. The climate is fairly cool throughout the hot season.

The area has some hill-streams and several water-veins seeping out from hilly inclines. Besides these, there are 2—3 artificial tanks at a lower altitude with perennial water-supply, half-a-dozen old out-of-use cisterns which receive some water supply throughout the year, a couple of wells on hill tops which during the wet season overflow and several miscellaneous pools and puddles that are so commonly formed during the wet season. From all these wet situations the material for the present study was collected during different seasons for the period 1953—56. The place was chosen, it being a convenient and profitable ground for botanical excursions since it harboured a rich Angiosperm-flora more or less representative of any region of the Western Ghats. The frequent botanical excursions were solely conducted by the author who was in charge of teaching Systematic Botany — and it was a welcome thing.

The collections that were made during the period were examined soon after, both in fresh and preserved (5 % formalin used) condition at the Rajaram College, Kolhapur, and the necessary notes were then written down. During the years 1958—59, the prepared slides of the material were once again examined but at the Gujarat College, Ahmedabad, despite of several handicaps, and later at the M. N. College, Visnagar. Of all these studies and observations, I present the following account.

From the examination of the material, it appeared that the Diatom flora is fairly rich and quite interesting. The genera *Eunotia* and *Pinnularia* are predominating. The genus *Frustulia* appeared to be characteristic of hilly situations. Again, the collections and study made for a period of about three-and-half years, it had become possible to record a range of variation occurring, at least in certain species of diatoms, in the natural habitat. Of such species mention may be made of *Eunotia pectinalis* v. *gibbulosus* VENKAT., *E. rostellata* HUST., *E. tumida* sp. nov., *Neidium oblique-striatum* A. S. v. *rostrata*

SKV., *Stauroneis phoenicenteron* EHR. f. *producta* GANDHI, *Pinnularia braunii* (GRUN.) CL., *P. pusilla* sp. nov., *P. panhalgarhensis* sp. nov., *P. major* (KÜTZ.) CL. v. *linearis* CL. and *Surirella subsalsa* W. SM. Another interesting feature noted was that most of these species possessed weakly silicified walls and markings, in some it was difficult to decipher very fine and delicate markings, especially in species of *Frustulia* and *Anomoeoneis exilis* (KÜTZ.) CL., but Leitz's phase-contrast microscope to a certain degree helped in determination of such fine markings.

On account of several factors I could not make many ecological studies of the periodic collections. But whatever little facility that was available and the study that could be made is indicated in the form of notes under individual species. These notes mostly refer to the occurrence, distribution, seasonal variation and frequency.

On the whole, the Diatom flora of this part was found to be worth the study in as much as that, 1) sixty-eight diatoms are recorded from the area of which twenty-three make new records for India and 2) eight species, five varieties and one form, tentatively, are considered to be new for Science. In this account illustrations and descriptions are avoided of such diatoms that are well known in the Indian Literature.

1. *Melosira dickiei* (THW.) KÜTZ. (Figs. 1—3).

VAN HEURCK, Treat. Diat., 1896, 444, pl. 19, f. 623; HUSTEDT, Bacil., 1930, 86, f. 42; SCHMIDT, A., Atlas Diat., 1874—1944, t. 182, f. 48—50 (= *Orthosira Dickieyii* THW.): — Cells 12. 8—19 μ in diameter and 10.5—11 μ high semi-cells, in short chains, cylindrical. Cells connected by small cushions. Sulcus absent. Inner rim thickened and gradually widening, often different in any two valves. Striae 15—16 in 10 μ, finely punctate in straight rows, often indistinct. Valves in top view circular with fine punctae probably arranged in radial rows, middle punctae scattered.

This species was first collected in 1955 and was continuously seen thereafter. It was found to inhabit springs and water veins seeping out from hilly inclines, appearing therein in the form of pale brown scum mostly after the rains. It usually occurred in good number till February, but during the hot seasons it was stray. A fairly distributed form but not abundant.

2. *Synedra ulna* (NITZ.) EHR.

HUSTEDT, Bacil., 1930, 151, f. 158—9: — Length 70—150 μ, breadth 5.5—6.8 μ and striae 8—10 in 10 μ.

This species was found in all seasons in smaller or larger numbers in all wet situations. It was very prolific in tanks with living and dead

vegetable matter. It was found to attain peak values from November to January.

3. *Synedra ulna* f. *staurodestituta* PANT. (Fig. 4).

CLEVE-EULER, A., Diat. Schwed. Finn. — II, 1953, 61, f. 382 b—c: — Valves 110—143 μ long and 6—6.6 μ broad, sublinear with ends abruptly narrowed and long-rostrate. Pseudoraphe narrow, linear. Central area not formed. Striae 9—10 in 10 μ, coarse.

4. *Eunotia praerupta* EHR. v. *bidens* GRUN. (Fig. 5).

VAN HEURCK, Treat. Diat., 1896, 302, pl. 9, f. 379; HUSTEDT, Bacil., 1930, 174, f. 213; BERG, A., genus Eunotia, 1939, 457 (=*E. praerupta bidens* (GRUN.) A. BERG); Diat. Sophia-Exped., 1945, 9, t. 2, f. 70; CLEVE-EULER, A., Diat. Schwed. Finn. — II, 1953, 127, f. 466 a—c (= *E. praebidens* (Å. BERG) A. CL. v. *genuina* A. CL.): — Valves 37.5—42 μ long and 10—12 μ broad, arcuate, dorsal side convex with a distinct concavity in the middle, ventral side uniformly but slightly concave; ends constricted on the dorsal side, capitate, somewhat obliquely subtruncate. Polar nodules small with a small part of raphe visible. Striae 10—12 in the middle and 13—14 in 10 μ at the ends, somewhat coarse.

BERG in 1939 regarded this species as *E. praerupta-bidens* and CLEVE-EULER, evidently basing her observations according to BERG, regarded it as *E. praebidens* v. *genuina*. The present author does not know of any explanation being offered by these scientists while departing from the normal course. Under this condition, it is felt here that the species be retained as such rather than building up nomenclatural difficulties.

This diatom was found as a stray form in most of the collections made from the region. It was usually found in pools, old-cisterns and in marginal slime of tanks, during August to February. In other months, it was seldom collected. A rare or stray form in the region.

5. *Eunotia pectinalis* (KÜTZ.) RABH. v. *curta* V. H. (Fig. 6).

CLEVE-EULER, A., Diat. Schwed. Finn. — II, 1953, 84, f. 409 b—d: — Length 21—24 μ, breadth 5.2 μ and striae 13—14 in 10 μ.

This diatom was found in a small number of pools and a cistern on Teen-darwaja side. It occurred as a stray form in pale brownish scum or encrustations formed by some Myxophyta. A rare form in the locality. From the collections nothing can be said regarding its periodicity.

6. *Eunotia pectinalis* v. *ventralis* (EHR.) HUST. (Fig. 7)

HUSTEDT, Algenfl. Bremen — IV, 1911, 276, t. 3, f. 26—27; Bacil.,

1930, 182, f. 241?; BERG, A., Genus Eunotia, 1939, 426, f. 1:25; CLEVE-EULER, A., Diat. Schwed. Finn. — II, 1953, 85, f. 409 k-l; VAN HEURCK, Treat. Diat., 1896, 301, pl. 9, f. 372 (= *E. pectinalis* v. *ventricosa* GRUN.): — Valves 70—76 μ long and 7—7.6 μ broad, slightly arcuate, dorsal side convex but straight in the middle, ventral side slightly concave, parallel with the dorsal side having a gibbosity in the middle; ends constricted on the dorsal side, well produced and weakly capitate or subcapitate. Polar nodules small. Striae 8—11 in 10 μ, irregularly disposed, coarse and slightly closely set towards the ends.

The illustration available of this diatom in the literature cited above shows a good deal of variations with regard to its apices which range from purely produced to slightly capitate, the ventral side having a slight bulge to a prominent gibbosity in the middle and in some cases slight inflations on ventral side terminations. However, the present form agrees well with CLEVE-EULER'S „f. 409 k" and HUSTEDT'S "t. 3, f. 27".

This diatom was collected in a small number from several large and small bodies of water around the hills. It was recorded during all seasons but rarely during the hot period. It was often found in pale brown films with decaying vegetable matter lying on borders of the wet situations, rarely epiphytic. Not quite common in the locality.

7. *Eunotia pectinalis* v. *gibbulosus* VENKAT. (Fig. 8)

VENKATARAMAN, G., S. I. Diat., 1939, 309, f. 22; GANDHI, H. P., Diat. Radhanagari, 1957, 47, pl. 13, f. 2: — Length 60—80 μ, breadth 6.6—7 μ and striae 9—13 in 10 μ.

Some of the specimens showed the dorsal side less gibbous in the middle part than in others, both from this as well as from other localities. From the observations of the species collected here, it seems that the margin of difference between this and *E. pectinalis* v. *ventralis* described above tends to be small. It may be that larger valves of length more than 70—80 μ, having distinct median gibbosity on the dorsal side with lateral elevations towards the apices, tend to lose them into a more or less straight wall in small specimens to appear like *E. pectinalis* v. *ventralis*. In the diatom illustrated presently it seems to find some emphasis of this kind, that the dorsal side has a feeble gibbosity in the middle and towards the ends the sides less elevated than in specimens recorded previously by different workers as well as some here also. However, the point whether *E. pectinalis* v. *gibbulosus* gives rise to *E. pectinalis* v. *ventralis* could not be ascertained for want of suitable material. This doubt needs varification by clone culture. It may be indicated that range of dimensions recorded by different workers, for *E. pectinalis* v. *gibbulosus* and *E.* v. — *ventralis*, are as follows: —

a) *Eunotia pectinalis* v. *gibbulosus*

Author		Length	Breadth	Striae in 10μ	
VENKATARAMAN	(1939)	42-120μ	5-8μ	7-11	
HUSTEDT	(1930)	?	?	?	(v. *ventralis*?)
BERG	(1939)	85-115μ	5-6μ	8-10	(f. *gibbosa*)
CLEVE-EULER	(1953)	80-160μ	5-7μ	7-10	(v. *gibbosa*)
GONZALVES & GANDHI	(1951)	125-134.5μ	8-9μ	8-11	
GANDHI	(1957)	96-111μ	8.5-9μ	8-11	
— (unpublished)	(1959)	98-120μ	8.8-9μ	10-12	

b) *Eunotia pectinalis* v. *ventralis*

Author		Length	Breadth	Striae in 10μ
BERG	(1939)	35-75μ	6-8 μ	12
CLEVE-EULER	(1953)	40-70μ	7 μ	8-11
in the present case		70-76μ	7-7.6μ	8-11

From the observation of these two tables, it becomes evident that *E. pectinalis* v. *gibbulosus* are larger forms than *E. pectinalis* v. *ventralis* and the range of dimensions recorded by VENKATARAMAN appears to be certainly not in keeping with those recorded by other workers, especially the lower range.

This diatom was also found in good number throughout the seasons and in several bodies of water during the years 1945—56. It often occurred in masses of dead vegetable matter forming pale brown matrix. It also was noted once or twice in a few samples collected from old cisterns. Fairly distributed in the locality.

8. *Eunotia pectinalis* v. *neglecta* GANDHI (Fig. 9)

GANDHI, H. P., Diat. Radhanagari. 1957, 47, pl. 13, f. 3—5 :— Length 43—53 μ, breadth 6.7—7 μ and striae 11—13 in 10 μ.

This diatom was found sparsely distributed in the area, often represented by stray specimens. However, it was noted as an all-season form mostly occurring in stagnant waters in cisterns and pools with rotting vegetable matter.

9. *Eunotia rostellata* HUSTEDT (Figs. 10—16).

SCHMIDT, A., Atlas Diat., 1874—1944, t. 289, f. 3—4; BERG, A., Diat. Sophia-Exped., 1945, 7, t. 2, f. 46; CLEVE-EULER, A., Diat. Schwed. Finn. — II, 1953, 87, f. 410 :— Valves 16—57 μ long and 6.6—7.5 μ broad, arcuate, linear, somewhat parallel in the middle

with ends constricted on the dorsal side, broadly produced and rounded but not at all capitate. Polar nodules small but distinct. Striae 12—16 in 10 μ, fine but distinct.

A table of typical dimensions noted for the species.

		Length	Breadth	Striae in 10μ
		16 μ	6.6μ	14—15
		23 μ	6.6μ	16
		26.2μ	7.2μ	14—16
		30 μ	7 μ	14
		47.6μ	7—7.5μ	13—14
		57μ	7.5μ	12—13
BERG	(1945)	19—35μ	5 μ	15—17
CLEVE-EULER	(1953)	13—45μ	5—6.5μ	15—17

Of this species several specimens were observed with a typical latitude of dimensions indicated in the above table and also those recorded by BERG and CLEVE-EULER, for the comparison. Again, several figures are given of the same depicting different sizes. All these illustrations seem to resemble very closely with three different species, viz. 1) *E. septentrionalis* ØSTRUP (HUSTEDT, Bacil., 1930, 179, f. 232), 2) *E. rostellata* HUST. and 3) *E. grunowii* Å. BERG v. *uplandica* A. CL. (CLEVE-EULER, A., Diat. Schwed. Finn. — II, 1953, 97, f. 421 j-r; BERG, Å., genus Eunotia, 1939, 437, f. 5 : 190), in the outline, typically narrowed, produced rounded ends with smaller polar nodules. These three species do not show much difference either in their outline, apices or the arrangement of striae though the striae number varies. Considering my examined material and setting to compare that with these three species, I, therefore, experience a certain amount of hardship. However, I place *E. septentrionalis*, out of consideration on the basis of length to breadth proportions and density of striae, although in larger forms L. : Br. proportions tend to be approximate. The dimensions given for *E. septentrionalis* are according to HUSTEDT (1930) 11—36 x 3.5—6 μ, striae 16—20 in 10 μ; CLEVE-EULER, A. (1953) 18—25 x 4—5 μ, str. 16—19 in 10 μ. While considering the above table it appears that the breadth in present forms does not much diminish with the diminishing length. Moreover, the larger forms have less number of striae per 10 μ.

The difficulty which arises now is that whether all the forms examined and referred to in the table be considered as a single, polymorphic species *E. rostellata* HUST., or two species as *E. rostellata* having denser striae and *E. grunowii* v. *uplandica* A. CL. (= f. *uplandica* according to Å. BERG) with less denser striae. The range of

dimensions given for *E. rostellata* more or less agrees as also the number of striae per 10 μ, with forms collected here of length 16—30 μ, shown in the table. And what that minor difference exists, may be taken for ecological variation. Now the forms of length range 47—57μ, that remain have less number of striae than the others, create hesitation. If these forms are considered with *E. grunowii* v. *uplandica*, they quite fit-in with CLEVE-EULER'S records which have striae range 10—13 in 10 μ. According to BERG, *E. grunowii* v. *uplandica*, has only 9—10.5 striae per 10 μ. In this event CLEVE-EULER'S and specimens recorded here admittedly deviate.

While looking to the given table again, the striae number seems to be diminishing in specimens of larger lengths, and in the case of *E. grunowii* v. *upplandica*, CLEVE-EULER and BERG giving different ranges of striae. I am not sure to what extent I would be right if I say that there seems to be an opening for solution of the present dilemma. If, *E. grunowii* v. *uplandica* be reviewed to *E. rostellata*, the latter being a polymorphic type exhibiting denser and denser striae in its smaller derivatives without having much change in form, then the difficulty seems to find a solution. I, therefore, adopt this view resting on my observations of forms of medium to smaller lengths. In this event — naturally — *E. grunowii* v. *uplandica* (= f. *uplandica* according to BERG) becomes *E. rostellata* HUST., which would have now the range of dimensions 13—140 μ x 5—10 μ, and striae 9—17 in 10 μ (9—13 in larger forms and 14—17 in smaller forms per 10 μ).

This species was collected from practically all wet situations in the area, in smaller or larger numbers during different seasons. It was found particularly in pale brown films formed on dead leafy matter, wet soils, rocks along the slowly flowing water veins and as encrustations in cisterns. A very common type in the locality. It was usaully more abundant from November to January.

10. *Eunotia veneris* (KÜTZ.) O. MÜLL. (Fig. 17)

HUSTEDT, Bacil., 1930, 182, f. 245 -— Length 11.5—16 μ, breadth 3.8 μ and striae 13—14 in 10 μ.

This species consisting of small forms was represented in association of *E. lunaris* (EHR.) GRUN., *E. alpina* (NAEG.) HUST. and others. It mostly occurred in brownish masses of matter lying loosely in slowly moving water veins and courses. In some cisterns also it was represented but rather uncertainly. Sparsely distributed in the locality. Not recorded during hot and rainy seasons.

11. *Eunotia lunaris* (EHR.) GRUN. (Fig. 18)

HUSTEDT, Bacil., 1930, 183, f. 249 :— Length 30—63 μ, breadth 3—3.3 μ and striae 14—15 in 10 μ.

This species occurred in all wet situations but in good number in stagnant waters of pools and cisterns. It was seen during all seasons but more during December to early February. Well distributed in the region.

12. *Eunotia alpina* (NAEG.) HUST. (Fig. 19)

HUSTEDT, Bacil., 1930, 185, f. 252 :— Length 42—45 μ, breadth 2.8 μ and striae 16—18 in 10 μ.

This species also occurred in several wet situations but rather sparingly. It was specially recorded from slowly flowing water courses around hills. It was rarely prolific in certain pools and cisterns. Not known during the hot season. A frequent form in the locality, except for the season indicated.

13. *Eunotia pseudoparallela* Å. BERG v. *densestriata* A. CL. (Fig. 20)

BERG, Å., genus Eunotia, 1939, 438, f. 2:84 (= *E. pseudoparallela* v. β); CLEVE-EULER, A., Diat. Schwed. Finn. — II, 1953, 89, f. 424 c: — Valves 14—16 μ long and 2.8 μ broad, arcuate, linear with parallel sides and obtusely rounded ends, ventral side with two notches one towards each end away from the polar nodules. Striae 18 in 10 μ, fine but clearly seen.

This diatom was found usually with *E. lunaris*, *E. alpina* and others in a small number. It was somewhat frequent during November to January, but stray or rare for rest of the year. It was mostly collected from smaller bodies of water occurring there with pale decaying vegetable matter. Not quite common in the locality.

14. *Eunotia hebridica* Å. BERG v. *bergii* v. nov. (Fig. 21)

Valvae 61—65 μ longae atque 10 μ latae, arcuatae, lineares, apicibus ad dorsum constrictis, productis ac subcapitato-rotundatis. Noduli polares distinctae. Striae 8—11 in 10 μ, distincte ac proxime positae in utroque apice.

Valves 61—65 μ long and 10 μ broad, arcuate, linear with ends constricted on the dorsal side, produced and subcapitate-rounded. Polar nodules distinct. Striae 8—11 in 10 μ, distinct and closely set towards the ends.

This diatom resembles well with the form *E. hebridica* v. β described and illustrated by BERG (BERG, Å., genus Eunotia, 1939, 457, f. 4 : 164), but for want of varietal name it has been so treated and named in honour of my esteemed friend.

This diatom was found in a small number from a over-flowing well situated on the hill top, sometimes from September to October, 1954. But from other parts of locality, it was found fairly frequently in pools and cisterns cluttered with dead vegetable matter. On one oc-

cassion during 1955, it was also collected from clusters of some liverworts growing around a continuously moistened rock on the hill-side near Waghdarwaja. Not quite common. Type slide Pan 1:136.

15. *Eunotia tumida* sp. nov. (Fig.s 22—25)

Frustula parva, late rectangularis is aspectu zonale. Valvae 13.3—14 μ longae atque 6.6—7.6 μ latae, minutae, margine dorsale valde tumida ventrale recta vel paululum concava, apicibus ad dorsum aliquantum depressis, productis ac rotundatis. Noduli polares minuti sed distincti. Striae 11—14 in 10 μ, tenues sed distinctae.

Frustules small, broadly rectangular in girdle view. Valves 13.3—14 μ long and 6.6—7.6 μ broad, small, dorsal side strongly tumid and ventral side straight or very slightly concave with ends feebly depressed on the dorsal side, produced and rounded. Polar nodules small but distinct. Striae 11—14 in 10 μ, fine but distinct.

This species does not correspond well to any of the similar looking types noted in the literature, hence it is tentatively considered to be a new species.

This species was collected in a good number from many wet situations of Panhalgarh hills, during practically all seasons of the years 1953—56. It was sometimes gregarious in some pools or slowly flowing water courses soon after the rains. However, during the hot season it was somewhat casual or stray. It was either found in pale brown films deposited on stones along the water courses or on continuously wet soils of pools, ditches or cisterns. A fairly common form. This species is also known to occur at several places on the Western Ghats, in similar situations. Type slide Pan 2:137.

16. *Frustulia saxonica* Rabh. (Figs. 26—27)

Cleve—Euler, A., Diat. Schwed. Finn. — V, 1952, 8, f. 1327 a—b :— Length 32.5—40 μ, breadth 8.4—10 μ and striae about 30 in 10 μ.

This is one of the very wide spread species in the area being found frequently in all collections made during different seasons of years 1953—56. Its favourite haunts were pools, cisterns, slowly flowing water courses and hill streams, but never noted in tanks, except once in 1955. It often occurred in pale brown films deposited on dead submerged leaves and in encrustations of cisterns as also on continuously moistened soils around the hills. Its prolific growth was noted usually during November to January, otherwise seen as a common form. It is also known from several hilly situations all along the Western Ghats.

17. *Frustulia saxonica* v. *linearis* A. Cl. f. *minor* Gandhi

Gandhi, H. P., Diat. Radhanagari, 1957, 52, pl. 13, f. 16 :— Length 36.5—38 μ, breadth 10 μ and striae over 30 in 10 μ.

This diatom was found along with the above type but somewhat less frequently. At one time during 1954, it was found to be gregarious in a certain reservoir and around an overflowing well on the hill top. Fairly well distributed in the locality as well as at several places on the Western Ghats. Its peak period probably was November or little earlier.

18. *Frustulia vulgaris* THW. v. *subcapitata* v. nov. (Figs. 28—29)

Valvae 32—34 μ longae atque 7.5—8 μ latae, lineares-ellipticae, apicibus constrictis ac late-subcapitatis. Raphe inter siliceas costas inclusa cum cornibus in nodulo centrale dilatatis. Area centralis elliptica. Striae 24—25 tenus 30 in 10 μ in utroque apice. Striae in medio radiales ac distinctae, indistincte punctatae.

Valves 32—34 μ long and 7.5—8 μ broad, linear-elliptical with constricted, broad subcapitate ends. Raphe between the siliceous ribs, horns in the central nodule widened. Central area elliptical. Striae 24—25 in the middle upto 30 in 10 μ towards the ends. Middle striae radial and distinct, indistinctly punctate.

This diatom agrees well with *F. vulgaris* THW. and its variety v. *capitata* KRASSKE (HUSTEDT, Bacil., 1930, 221, f. 327—8), in the general outline, radial striae, central and polar nodules. However, several specimens collected of this diatom from year to year showed less capitate ends. It is therefore felt here to name these under a new varietal status.

This diatom was represented well in the locality occurring in pale brown films lying either in stagnant water or slowly flowing water courses around the hills. It was well noted during the wet and cool seasons but sparsely during the summers. Type slide Pan 3:138.

19. *Frustulia indica* sp. nov. (Figs. 30—31)

Valvae 45—60 μ longae atque 7.8—8.6 μ latae, lineares, paulum triundulatae, apicibus constrictis, cuneatis ac plus minus producto rotundatis. Raphe inter siliceas costas inclusa, costae aliquantum curvatae, atque ad partem mediam dilatatae. Area centralis aliquantum dilatata ac elliptica. Noduli polares elongati. Striae circiter 35 in 10 μ, tenuissime punctate, punctae fere indistinctae.

Valves 45—60 μ long and 7.8—8.6 μ broad, linear, slightly triundulate, ends constricted, cuneate and more or less produced-rounded. Raphe between the siliceous ribs, ribs slightly bent and at the middle part widened. Central area slightly widened and elliptical. Polar nodules elongated. Striae about 35 in 10 μ, finely punctate, punctae almost indistinct.

This diatom does not correspond to any of the known species, hence it is tentatively considered to be a new species. A very common diatom richly represented from November to February. Type slide Pan 4:139

20. *Neidium amphigomphus* (Ehr.) Cl. v. *obtusum* A. Cl. (Fig. 32)

Cleve-Euler, A., Diat. Schwed. Finn. — IV, 1955, 115, f. 1168 d :— Valves 40.8—50 μ long and 11.5—13 μ broad, elliptical-lanceolate with feebly constricted or not, subcuneate rounded ends. Raphe thin and straight with central pores bent in opposite directions and terminal fissures shortly bifurcated. Axial area very narrow; central area slightly obliquely elliptical, fairly large. Striae 20—23 in 10 μ fine but clearly punctate, slightly obliquely set in the middle and convergent at the ends, crossed by a few longitudinal furrows near the margins.

This diatom was represented in only a few samples made during 1954, usually in small numbers. These samples were obtained from some pools and cisterns around the hills. During later years it was irregularly observed as a sort of deposition on dead vegetable matter, loosely lying in some pools only. Not properly known in the locality.

21. *Neidium obliquestriatum* A. S. v. *rostrata* Skv. (Fig.s 34—36)

Skvortzow, B. W., Diat. Kizaki-lake, 1937, 30, pl. 4, f. 16: :— Valves 47.6—57 μ long and 10.5—11 μ broad, linear-elliptical to lanceolate-elliptical with constricted, broadly produced, cuneate to subcuneate ends. Raphe thin and straight with central pores conspicuously bent in opposite directions and terminal fissures bifurcated. Axial area narrow, linear; central area large, obliquely rectangular. Striae 22—26 in 10 μ, lineate or lineolate and obliquely disposed throughout, crossed by 1—3 hyaline longitudinal furrows near the margins.

Of this diatom several specimens were examined during different seasons and years. All these showed some difference in their form and also in their dimensions and structure. All these differences are indicated in the illustrations. Regarding dimensions that were typically noted, the following table may be referred to:—

Length:	Breadth:	Striae in 10 μ
41 μ	11.5μ	22—23
47.6μ	10.5μ	24—26
48 μ	11 μ	—do—
57 μ	10.5μ	22—24
61 μ	15 μ	24 according to Skvortzow

This species was recorded all the year round in the area from several bodies of water in smaller or larger numbers. It was often found mixed up in brownish decaying vegetable matter and some My-

xophyta. A certain water course in a garden near Wagh-darwaja yielded it in good number. Its period of good growth was noted to vary from September to November. A fairly common form in the locality.

22. *Neidium panhalgarhensis* sp. nov. (Fig. 33)

Valvae 47—50 μ longae atque 8.5—8.7 μ latae, lineares, paululum tumidae in medio, apicibus obtuso-cuneatis. Raphe tenuis et recta, poris centralibus inclinatis in directione contraria, fissuris terminalibus bifurcatis. Area axialis angustissima; area centralis ampla, elliptica vel circularis. Striae 28—30 in 10 μ, tenuissime punctatae, fere indistinctae, paululum oblique evolutae in medio atque convergentes ad apicem, sulcis paucibus longitudinalibus interruptis ad margines.

Valves 47—50 μ long and 8.5—8.7 μ broad, linear, feebly tumid in the middle with obtusely-cuneate ends. Raphe thin and straight with central pores bent in opposite directions and terminal fissures bifurcated. Axial area very narrow; central area fairly large, elliptical to circular. Striae 28—30 in 10 μ, very finely punctate almost indistinct, feebly oblique in the middle and somewhat convergent at the ends, crossed by a few longitudinal furrows near the margins.

This species does not agree with any of the known types, hence it is regarded as a new species. Noted as rare. Type slide Pan 3:138.

23. *Stauroneis phoenicenteron* Ehr.

Hustedt, Bacil., 1930, 255, f. 404 :— Length 80—110 μ, breadth 18—22 μ and striae 14—16 in 10 μ.

This species occurred as a stray form in a number of samples collected during different seasons. In certain larger pools and tanks it occurred fairly in marginal scum. A constant but stray form.

24. *Stauroneis phoenicenteron* f. *gracilis* Dippel (Fig. 37)

Hustedt, Bacil., 1930, 255; Skvortzow, B. W., Diat. Vladivostok, 1938, 254, pl. 1, f. 36; Cleve-Euler, A., Diat. Schwed. Finn. — III, 1953, 210, f. 944 g? (= v. *gracilis* (Ehr.) Dip.) :— Valves 110—120 μ long and 18—20 μ broad, narrowly rhombic-lanceolate with produced rounded ends. Raphe thick with central pores conspicuous and terminal fissures curved. Axial area narrow, linear; central area a stauros, somewhat more widened near the margins. Striae about 20—22 in 10 μ, becoming strongly radial towards the ends, fine but clearly punctate.

This diatom was seen mostly in very small number from September to February, otherwise very rarely seen. It was collected from some pools and cisterns near Wagh-darwaja. Rather rarely seen in the area.

25. *Stauroneis phoenicenteron* f. *producta* GANDHI (Figs. 38—40)

GANDHI, H. P., Diat. Hirebhasgar, 1958, 252, f. 7 :— Length 58—90 μ, breadth 12.6—16 μ and striae 22 in 10 μ.

Of this diatom some illustrations are given to suggest the form change that was found to occur. Here the deviations are noted regarding the outline and the apices.

This diatom was found very frequently throught the region and during all seasons. It was particularly found to be prolific during January-February, otherwise fairly noted. In certain cisterns it was more abundantly formed in decaying vegetable matter. A common form. Also recorded from other places on the Western Ghats. Type slide Pan 5:140.

26. *Stauroneis anceps* EHR.

HUSTEDT, Bacil., 1930, 256, f. 405 :— Length 50—70 μ, breadth 9—13 μ and striae 22—24 in 10 μ.

This diatom was found in a few samples but in good number every year from 1954—56. It was usually found in cisterns, tanks and larger pools around the hills. An all-season form but sparingly seen during the hot and monsoon seasons.

27. *Stauroneis anceps* v. *linearis* (KÜTZ.) V. H. (Fig. 41)

VAN HEURCK, Treat. Diat., 1896, 160, pl. 1, f. 56; HUSTEDT, Bacil., 1930, 256, 407? (= f. *linearis* (EHR.) CL.); CLEVE-EULER, A., Diat. Schwed. Finn. — III, 1953, 208, f. 943 f (= v. *linearis* GRUN.); BERG, Å., Diat. Sophia-Exped., 1945, 12, pl. 3, f. 115 (= v. *hyalina* BR. & PERAG.) :— Valves 36—48 μ long and 8.2—10 μ broad, linear-elliptical with somewhat abruptly narrowed, rostrate rounded ends. Raphe thin and straight. Axial area very narrow; central area a somewhat linear stauros. Striae 26—28 in 10 μ, radial and finely punctate.

While going through the available literature, I find that forms of the present features have been named differently but wherever the similar varietal epithets appear the illustrations tend to show diverse features, e.g. VAN HEURCK, HUSTEDT and CLEVE-EULER give three different illustrations for *S.* — v./f. *linearis* indicating different authors. Whereas, VAN HEURCK and BERG illustrate similar forms under different names. I, therefore, experience much difficulty regarding the correct identity of the present specimens. However, I regard present specimens according to VAN HEURCK'S since they agree very closely.

This diatom was found frequently in pools, puddles, cisterns, streams and some water courses in the area. It was more abundantly noted from November to January than during the rest of the seasons.

It occurred mostly in brownish masses of matter but sometimes in encrustations also. A common diatom in the area.

28. *Anomoeoneis exilis* (KÜTZ.) CL. (Figs. 42—43)

HUSTEDT, Bacil., 1930, 264, f. 429 :— Valves 15—22 μ long and 3.8—4.5 μ broad, lanceolate with capitate rounded ends. Raphe thin and straight. Axial area very narrow; central area small, rounded or elliptical. Striae about 30 in 10 μ, radial, finely punctate, crossed by several longitudinal hyaline ribs 12—13 in 10 μ, irregularly formed. On the whole the structure was very fine and was difficult to observe.

This species was collected from an overflowing well on the hill top, some pools and cisterns. It occurred in pale brownish scum or slime lying on soil, dead vegetable matter etc. It was well represented during winter and spring seasons but otherwise sparingly seen. A water course in a garden near Wagh-darwaja also yielded it usually in good numbers. A moderately distributed species.

29. *Navicula cuspidata* KÜTZ.

HUSTEDT, Bacil., 1930, 268, f. 433 :— Length 60—100 μ, breadth 19—21 μ and striae: longitudinal 24—26 and transverse 14—16 in 10 μ.

This species occurred rather rarely in the locality. Each time during each year usually a few specimens were observed. These specimens sometimes with craticular plates also were seen.

30. *Navicula cuspidata* v. *ambigua* (EHR.) CL.

HUSTEDT, Bacil., 1930, 268, f. 434 :— Length 70—73 μ, breadth 20—22 μ and striae: longitudinal 26 and transverse 16—18 in 10 μ.

This diatom was with or without the company of the above species, was seen rather more frequently in the area. Practically every algal sample contained it in usually smaller number with or without craticular stages. A frequent form in the area.

31. *Navicula mutica* KÜTZ. (Figs. 44—45)

HUSTEDT, Bacil., 1930, 274, f. 453 a; LUND, J. W. G., Brit. Soil Alg. 1946, 71, f. 6 A-I :— Length 11—14 μ, breadth 5—5.2 μ, and striae 18—20 in 10 μ.

Of this species two illustrations are given to show the form change that was noted in a collection.

The collections made from this region indicate that this species is wide spread, occurring during all seasons in smaller or larger numbers. It was noted also from wet soils and clusters of mosses and liverworts. However, it was rarely gregarious.

32. *Navicula viriduloides* sp. nov. (Fig. 46)

Valvae 30—38 μ longae atque 8—8.5 μ latae, lineares-ellipticae, apicibus aliquantum abrupte constrictis, producto-rostratis vel subcapitatis. Raphe tenuis et recta, poris centralibus distinctis et unilateraliter inclinatis, fissuris terminalibus curvatis. Area axialis linearis cum hyalino; area centralis magna item hyalina, paulum unilateraliter evoluta. Striae 14—16 in 10 μ, lineatae, radiales in medio atque convergentes in utroque apice.

Valves 30—38 μ long and 8—8.5 μ broad, linear-elliptical with somewhat abruptly narrowed, produced rostrate to subcapitate ends. Raphe thin and straight with central pores distinct and unilaterally inclined and terminal fissures curved. Axial area linear and hyaline; central area large and likewise hyaline, slightly unilaterally formed. Striae 14—16 in 10 μ, lineate, radial in the middle and convergent at the ends.

This species resembles *N. viridula* Kütz. v. *capitata* Mayer (Cleve-Euler, A., Diat. Schwed. Finn. — III, 1953, 151, f. 805 e-g), in the outline, apices and arrangement of striae. However, it differs from it in having denser striae and their equidistant setting. The more characteristic feature is the presence of a hyaline zone surrounding the raphe besides the central pores unilaterally bent and conspicuous within a clear space. It is therefore considered as a new species.

This species was found as a common form throughout the region and was collected all the year round from several bodies of water both large and small. However, it was more frequent during January to February. It usually occurred in pale masses of matter along with other species. Type slide Pan 5:140—140 b

33. *Navicula viriduloides* v. *lanceolata* sp. et v. nov. (Fig. 47)

Valvae 30—36 μ longae atque 8.4—8.8 μ latae, late-lanceolatae, apicibus constrictis, productis ac subcapitatis. Striae 14—16 in 10 μ. In ceteris ut typus.

Valves 30—36 μ long and 8.4—8.8 μ broad, broadly lanceolate with constricted, produced and subcapitate ends. Striae 14—16 in 10 μ. In all other characters like the above type.

This diatom was found usually along with the type but less commonly. Again a wide spread form. Type slide Pan 6:141.

34. *Navicula zanoni* Hustedt (Fig. 48)

Hustedt, Diat. Albert nat.-park, 1949, 92, t. 5, f. 1—5 :— Valves 28—36 μ long and 6.6—8 μ broad, narrowly lanceolate with narrowed, constricted, produced acutely rounded ends. Raphe thin and straight. Axial area narrow; central area circular or subquadrate. Striae 13—14 in 10 μ, lineate, radial in the middle and convergent at the ends.

This species occurred fairly in several collections made over years (1953—56). It was common in certain cisterns near Teen-darwaja and some pools but in other similar habitats it occurred casually. In other bodies of water and streams it was usually found in smalller number or absent. Fairly distributed in the area. A constant and all season form.

35. *Navicula venezuelensis* HUST. (Figs. 49—50)

HUSTEDT, Diat. Lago de Maracaibo, 1956, 115, f. 33—36 :— Valves 30—36 μ long and 5—6 μ broad, linear-lanceolate with cuneate ends. Raphe thin and straight with curved terminal fissures. Axial area quite narrow; central area small roundish or subquadrate. Striae 12—13 rarely 14 in 10 μ, coarsely but not very distinctly lineate, radial in the middle and convergent and somewhat closely set at the ends.

I here offer my grateful thanks to Dr. HUSTEDT, for while studying this species I was very much in difficulty regarding its determination and at that juncture the unexpected arrival of the above quoted paper from him rescued me.

This species was collected from some cisterns, a spring on the side of Teen-darwaja and an over-flowing well atop the hill. It was found in brownish matter lying on the soil or with some vegetable matter. Many other samples casually represented it. Not quite common in the locality. It was first observed in November 1954 and thereafter it continued to be known from similar situations.

36. *Navicula panhalgarhensis* sp. nov. (Fig. 51)

Valvae 38—46 μ longae atque 6.2—6.5 μ latae, lineares, apicibus aliquantum abrupte constrictis, elongato-rostratis. Raphe tenuis et recta, fissuris terminalibus curvatis. Area axialis angustissima; area centralis ampla, rotundata. Striae 12—13 in 10 μ, lineatae, valde radiales in medio atque convergentes in utroque apice, 1—2 mediae striae breviter cum distantiis evolutae.

Valves 38—46 μ long and 6.2—6.5 μ broad, linear with somewhat abruptly constricted and long rostrate ends. Raphe thin and straight with terminal fissures curved. Axial area very narrow; central area large and circular. Striae 12—13 in 10 μ, lineate, strongly radial in the middle and convergent at the ends, 1—2 middle striae short and distantly formed.

This species resembles *N. cari* EHR. v. *linearis* (ØST.) A. CL. (CLEVE-EULER, A., Diat. Schwed. Finn. — III, 1953, 153, f. 810 c), in the outline and produced ends. However, it differs in dimensions and the feature of the middle striae which appear to be characteristic. It is, therefore, considered to be a new species.

This species was collected in a small number usually from pools, some cisterns and certain of the water veins seeping out from hilly inclines. A few specimens also were noted in a collection from a garden pool near Teen-darwaja. It did not appear as a constant form. Type slide Pan 7:142.

37. *Navicula radiosa* KÜTZ. v. *minutissima* (GRUN). CL. (Fig. 52)

CLEVE-EULER, A., Diat. Schwed. Finn. — III, 1953, 156, f. 816 o :— Valves 20—22 μ long and 4—4.5 μ broad, lanceolate with somewhat produced acutely rounded ends. Raphe thin and straight. Axial area very narrow; central area small, elliptical, rounded or subquadrate. Striae 14—18 in 10 μ, indistinctly lineate, rather faint, radial in the middle and convergent at the ends and somewhat closely set.

This diatom was found in a number of small bodies of water as well as in cisterns. It usually occurred in smaller numbers in brownish masses of matter. It was first observed during February 1954 and then was usually collected during all seasons though sparingly. An infrequent form.

38. *Pinnularia braunii* (GRUN.) CL. (Figs. 53—56)

HUSTEDT, Bacil., Sarek., 1924, 566, t. 19, f. 15; Bacil., 1930, 319, f. 577; CLEVE-EULER, A., Diat. Schwed. Finn. — IV, 1955, 24, f. 1020 a-c (c= HUSTEDT'S form); SCHMIDT, A. Atlas Diat., 1874—1944, t. 45, f. 77—78 (= *Navicula brauniana* GRUN.); VAN HEURCK, Treat. Diat., 1896, 173, pl. 2, f. 95 (= *Nav. braunii* GRUN.) :— Valves 35—43 μ long and 6.6—7.6 μ broad, narrowly elliptical-lanceolate with produced, narrowly capitate ends. Raphe thin and straight with central pores unilaterally bent and closely set, terminal fissures distinctly curved. Axial area narrow to broadly lanceolate; central area widely rhombic and reaching the sides. Striae 10—13 in 10 μ, coarse, gradually shortened in the middle and radial, at ends convergent and closely set.

A table of typical dimensions noted for the species

Author:		Length:	Breadth:	Striae in 10μ
		35μ	7 μ	12—13
		38μ	7.6μ	10—12
		38μ	7.6μ	11—13
		43μ	7.6μ	10—13
		44μ	7.5μ	12—13
VAN HEURCK		40μ	—	10—11
HUSTEDT	(1930)	30—60μ	8—12μ	11—12
CLEVE-EULER	(1955)	30—50μ	7.5—12μ	11—12

This species was collected usually in good number from practically all wet situations in the area during different parts of years 1953—56. It occurred as a common species and perhaps more abundantly during December to January. The local specimens represented some amount of variations in their outline and structure as represented in illustrations 53—56. However, all the specimens collected here agree well with VAN HEURCK'S *Navicula (Pinnularia) braunii* GRUN. and SCHMIDT'S (Atlas) *Nav. brauniana* GRUN., which have length to breadth proportions 5.8 : 1, whereas the local ones have L. : Br. = 5—5.8 : 1. While comparing these with those described by HUSTEDT and CLEVE-EULER which have L. : Br. = 4—5 : 1, then specimens of this place are distinctly slimmer. With the exception of this feature, no other departures from *P. braunii* (GRUN.) CL., are found.

Further, CLEVE-EULER'S attempt to distinguish HUSTEDT'S *P.braunii* as *P. braunii* v. *marginata* (HUST.) A. CL., however could in no event be supported here, since local specimens from year to year collections evidently showed striations varying in their length which tended to connect CLEVE-EULER'S *P.*—v. *genuina* A. CL. with *P.*—v. *marginata*. This point is being clearly indicated in figures 53—56. HUSTEDT already has stated that the striae often are shortened, and I should think he has illustrated such forms alone in works referred to above. In the light of above considerations, the local specimens could not be assigned to any new taxa on the mere basis of length to breadth proportions which on the other hand approximate with those given by VAN HEURCK and others.

39. *Pinnularia conica* GANDHI (Figs. 57—58)

GANDHI, H. P., genus Pinnularia, 1957, 847, f. 9—10 : — Length 58—63 μ, breadth 9—10.5 μ and striae 9—11 in 10 μ.

This species occurred in many collections in smaller or larger number during different seasons inhabiting brownish masses of matter or decaying vegetable matter. It was noted to be more frequent during September to November than otherwise. A common species in the region.

40. *Pinnularia pusilla* sp. nov. (Figs. 59—62)

Valvae 18—37.5 μ longae atque 3.8—5.6 μ latae, lineares, plus minus marginibus cum lineis aeque distantibus, apicibus aliquantum abrupte constrictis atque producto-rotundatis vel leniter subcapitatis. Raphe tenuis et recta, poris centralibus unilateraliter inclinatis paulum proximis; fissuris terminalibus curvatis. Area axialis late lanceolata; area centralis amplissime rhomboidea ad latera perveniens. Striae 10—15 in 10 μ, valde radiales in medio ac convergentes in utroque apice, striae in parte media gradatim abbreviatae.

Valves 18—37.5 μ long and 3.8—5.6 μ broad, linear, more or less with parallel sides and ends somewhat abruptly constricted, produced rounded or feebly subcapitate. Raphe thin and straight with central pores unilaterally bent and somewhat closely set, terminal fissures curved. Axial area broadly lanceolate; central area widely rhomboid and reaching the sides. Striae 10—15 in 10 μ, strongly radial in the middle and convergent at the ends, middle striae gradually abbreviated.

This species appeared to be very variable and seemed to show probably different phases from season to season or year to year as understood from collections made from the same and similar habitats in the area. The different phases observed are given in figures 59—62 and the typical dimensions recorded are indicated in the following table:

A table of typical dimensions noted

Length:	Breadth:	Striae in 10 μ
18 μ	3.8 μ	11—12
20 μ	5.3 μ	10—13
23 μ	4.2 μ	11—12
23.5 μ	4.5 μ	14—15
26.5 μ	4.7 μ	11—12
28 μ	4.6 μ	10—12—13
37.5 μ	5.6 μ	10—12

Further, the species to which present set of specimens more or less agree, are the following:

1. *Pinnularia interrupta* f. *minor* B. PET. (PETERSEN, Aërial Alg., 1928, 405, f. 25, dimensions 22—30 x 4.8—6 μ, str. 14/10 μ = *P.*—v. *minor* (B. PET.) A. CL. (CLEVE-EULER, Diat. Schwed. Finn.—IV, 1955, 63, f. 1088 k—n, dimensions 22—45 x 5—7.5 μ, str. 14—16/10 μ), in the later case ends are shown to be more strongly capitate.

2. *P. subcapitata* GREG. v. *subrobusta* A. CL. (CLEVE-EULER, ibid., 65, f. 1090 h. dimensions 40—60 x 5.7 μ, str. 11—13) this form with produced ends corresponds with some of the present ones.

3. *P. stauroptera* (RABH.) CL. v. *minuta* MAYER (CLEVE-EULER, ibid., 68, f. 1091 o—p, dimensions 35—75 x 7—9.5 μ, str. 10—11) it has the same features as in the above case no. 2.

4. *P. stauroptera* v. *minuta* f. *medioconstricta* A. CL. (CLEVE-EULER, ibid., f. 1091 r—s), here the sides are slightly concave a feature also is known in some of the present specimens.

5. *P. lapponica* HUST. (HUSTEDT, Diat. Abisko, 1942, 122, f. 43—45, dimensions 19—33 x 4.5 μ str. 14—16/10 μ) in this form ends are more capitate and the central area does not reach the sides.

6. *P. subcapitata* GREG. (SCHMIDT, Atlas Diat., 1874—1944, t. 44, f. 56) this species fig. 56 appears like some of the forms observed here with rostrate apices, but fig. 55 is very different as compared to the other.

However, the present set of specimens differ from all the above named species in respect of axial area being very large-lanceolate and central area widely rhomboid due to gradual abbreviation of striae in the middle zone. Again, the specimens of present set show two kinds of apices, viz. in some, clearly rostrate rounded and in others weakly subcapitate or subcapitate. The set with rostrate apices agrees with nos. 2, 3, 4, 6 in the outline and more or less in the number of striae/10 μ, whereas the other set with feebly capitate apices somewhat compares with nos. 1, 5. But then differences are such that no satisfactory all out comparision could be made with any one type. Moreover, certain of the specimens noted here have much narrower valves. Hence it is understood here that present specimens are a new species of poly-phasic nature, at least I consider it to be so provisionally.

This species was collected in smaller or larger numbers from variety of wet situations, throughout the region during all seasons. However, collections made during November to February period showed it more frequently. This species was found to inhabit brownish masses of matter lying on wet soils, dead leafy matter, submerged stones or other objects and occassionally the encrustations of some cisterns. A common type in the region. Type slide Pan 8 : 143.

41. *Pinnularia interrupta* W. SM. f. *minor* B. PET. (Fig. 63)

PETERSEN, J. B., Aërial Alg., 1928, 405, f. 25 :—Valves 28—29.5 μ long and 6.5—6.7 μ broad, linear with somewhat abruptly narrowed produced subcapitate ends. Raphe thin and straight. Axial area narrow, linear-lanceolate; central area large, rhomboid and reaching the sides. Striae 13—14 in 10 μ, radial in the middle and convergent at the ends.

A few specimens were usually collected from tufts of wet mosses and brownish matter formed on sides of water veins seeping out from hilly inclines. A sample from an over-flowing well collected in 1944 also contained it but very sparingly. Uncommon in the area.

42. *Pinnularia panhalgarhensis* sp. nov. (Figs. 64—66)

Valvae 67—96.4 μ longae atque 12.3—12.8 μ latae, lineare-lanceolatae, marginibus paulum triundulatis, apicibus constrictis, productis, subcapitatis vel capitatis rotundatis. Raphe paulum undulata vel subcomplexa, ornata poris centralibus aliquantum unilateraliter inclinatis, fissuris terminalibus crassis, semi-circularibus oblique evo-

lutis. Area axialis ampla, 1/5—1/4 latitudinis valvae, lineare-lanceolata; area centralis plus minus dilatata, rhomboidea, tenuis versus ad latera perveniens, unilateraliter dilatata vel unilateraliter perveniens ad latera. Striae 8.5—11 in 10 μ, crassae, radiales in medio ac convergentes in utroque apice.

Valves 67—96.4 μ long and 12.3—12.8 μ broad, linear-lanceolate with sides feebly triundulate and ends constricted, produced subcapitate to capitate rounded. Raphe slightly undulate to subcomplex with central pores slightly unilaterally bent and terminal fissures semicircular, coarse and oblique. Axial area fairly wide, 1/5—1/4 the width of the valve, linear-lanceolate; central area more or less widened rhomboid, narrow while reaching the sides or unilaterally dilated to unilaterally reaching the side. Striae 8.5—11 in 10 μ, coarse, radial in the middle and convergent at the ends.

This species seems to be related to *P. graciloides* Hust., *P. microstauron* (Ehr.) Cl., *P. divergens* W. Sm. and other members of the Divergentes group, in feature of striae, axial and central areas, but it does not agree satisfactorily with any one type. It is therefore considered to be a new species and put under the Divergentes group.

Within the cycle of this species, quite a degree of variation seemed to exist intergrading the individual specimens. The illustrations given show some of the typical representatives of the series. Here, it was also known that the smaller specimens seemed to possess a few more striae per 10 μ, and the central area more uniformly developed — reaching the sides.

This species was collected in varying number from several such bodies of water which had perennial supply. It was usually found to inhabit brownish masses of dead vegetable matter or occasionally the films of Myxophyta encrusting the cisterns. A more or less all season form but was seen more in number usually in November to December. Type slide Pan 9 : 144.

43. *Pinnularia panhalgarhensis* v. *lanceolata* sp. et v. nov. (Fig. 67)

Valvae 70—78 μ longae atque 12.3—12.5 μ latae, sublanceolatae, marginibus paulum triundulatis, apicibus leviter constrictis, lateproducte rotundatis. Raphe, area centralis ut in typo. Area centralis ampla, ad latera dissimiliter perveniens. Striae 9—10 in 10 μ. In ceteris ut typus.

Valves 70—78 μ long and 12.3—12.5 μ broad, sublanceolate, margins feebly triundulate with slightly constricted, broadly produced rounded ends. Raphe and axial area as in the above type. Central area large, dissimilar while reaching the sides. Striae 9—10 in 10 μ. In all other characters like the type.

This diatom was found usually in smaller number than the type

from the same habitats. Not common in the area. Type slide Pan 10 : 145.

44. *Pinnularia legumen* EHR. v. *interrupta* v. nov. (Fig. 68)

Valvae 75—82 μ longae atque 12.3—12.5 μ latae, lineares, marginibus distincte triundulatis, apicibus valde producto-rotundatis. Raphe crassa et subcomplexa, poris centralibus paulum unilateraliter inclinatis ac fissuris terminalibus crassis et paulum curvatis. Area axialis modice lata, linearis; area centralis ampla, rhomboidea, ad latera perveniens. Striae 12—13 in 10 μ, crassae, valde radiales in medio ac convergentes in utroque apice.

Valves 75—82 μ long and 12.3—12.5 μ broad, linear with distinctly triundulate sides and strongly produced rounded ends. Raphe thick and subcomplex with central pores slightly unilaterally bent and terminal fissures coarse and slightly curved. Axial area fairly broad, linear; central area wide, rhomboid and reaching the sides. Striae 12—13 in 10 μ, coarse, strongly radial in the middle and convergent at the ends.

This diatom agrees very closely *P. legumen* v. *cuneata* HUST. (SCHMIDT, A., Atlas Diat., t. 392, f. 11), in the outline, axial and central area and the setting of the striae. However, the present specimen differs in having central area extending the sides and somewhat closer striae. It is therefore considered to be a new variety.

This diatom was collected in a small number or as a stray form from some pools and cisterns. It occurred among the masses of dead vegetable matter. Not regularly collected during different seasons or years. A rare diatom in the area. Type slide Pan 11 : 146.

45. *Pinnularia esox* EHR. v. *capitata* GANDHI (Fig. 68)

GANDHI, H. P., genus Pinnularia, 1957, 849, f. 17:—Length 70.8—80 μ, breadth 12.3—12.7 μ and striae 10 in 10 μ.

This diatom was collected from some pools and water veins seeping out from hilly inclines near Teen-darwaja. A casual diatom in the area.

46. *Pinnularia major* (KÜTZ.) CL. v. *linearis* CL. (Fig. 70—72)

CLEVE-EULER, A., Diat. Schwed. Finn.—IV, 1955, 70, f. 1094 c—e:—Valves 103—106 μ long and 19—23 μ broad, linear with more or less broadly rounded ends, in some cases middle part obscurely dilated. Raphe thick, simple with central pores slightly unilaterally bent and terminal fissures thick, somewhat obliquely semi-circular. Axial area linear about 1/4 the width of the valve; central area somewhat unilaterally widened but small. Striae 7—7.5 rarely upto 8 in 10 μ, thick, radial in the middle and convergent at the ends with narrow longitudinal band.

This diatom was found fairly frequently in the region. It occurred in tanks, pools and perennially wet situations around the hills. Stray specimens also were collected from certain water courses. It was collected during different seasons but more in number during February to March. A fairly distributed, probably an all season form, in the area.

47. *Pinnularia sudetica* HILSE v. *commutata* (GRUN.) CL. f. *obtusata* f. nov. (Figs. 73—74)

Valvae 52—59 μ longae atque 10—10.5 μ latae, lineares, marginibus cum lineis aeque distantibus, apicibus obtuso-rotundatis. Raphe crassa et complexa, ornata poris centralibus distincte ac paulum unilateraliter inclinatis, fissuris terminalibus semi-circularibus. Area axialis modice lata-linearis, circiter 1/4—1/3 latitudinis valvae; area centralis plus minus unilateraliter circularis. Striae 10—13 in 10 μ, crassae, leniter radiales in medio ac convergentes in utroque apice, vittae longitudinales tenues indistrincte evolutis.

Valves 52—59 μ long and 10—10.5 μ broad, linear, sides parallel and ends obtusely rounded. Raphe thick and complex with central pores distinct and slightly unilaterally bent, terminal fissures semicircular. Axial area moderately broad, linear about 1/4—1/3 the width of valve; central area more or less unilaterally circular. Striae 10—13 in 10 μ, thick, slightly radial in the middle and convergent at the ends, longitudinal bands narrow and indistinctly formed.

This diatom agrees well with *P. sudetica* HILSE v. *commutata* (GRUN.) A. CL. (CLEVE-EULER, A., Diat. Schwed. Finn.—IV, 1955, 75, f. 1105 b—d), in the outline, organisation of striae, range of dimensions and other details. However, it differs in having strongly parallel sides and very obtusely rounded ends. It is therefore, considered as a new form.

This diatom was collected usually in good number from various bodies of water but particularly from more or less permanently wet places. It was found usually in brownish masses of dead vegetable matter but also in encrustations of cisterns. It was more numerous during September to November and during the summers it occurred rather sparingly. However, it was noted as an all season form in the area, a common type. Type slide Pan 12 : 147.

48. *Amphora veneta* KÜTZ.

HUSTEDT, Bacil., 1930, 345, f. 631:—Length 14—24 μ, breadth 7—9 μ and striae 18—20 in the middle and at the ends more denser in 10 μ.

This species was seen quite frequently in the area during all seasons in all wet situations. A very common form in the area.

49. *Cymbella pseudocuspidata* sp. nov. (Fig. 75)

Valvae 26.5—30 μ longae atque 8.5—8.7 μ latae, asymmetricae, subelliptico-lanceolatae, margine dorsale valde convexa, margine ventrale leniter convexa et in medio fere recta, apicibus plus minus abrupte constrictis ac rostratis. Raphe paulum excentrica, subcurvata, poris centralibus minutis, fissuris terminalibus versus marginem dorsalem flexis. Area axialis tenue-lanciolata; area centralis ampla, plus minus circularis et in parte media dilatata. Striae12—13 in 10 μ, regulariter positae, indistincte punctatae, ubique radiales ac 2—3 striae mediae ad marginem dorsalem abbreviatae.

Valves 26.5—30 μ long and 8.5—8.7 μ broad, asymmetrical, subelliptical-lanceolate, dorsal side strongly convex, ventral side slightly convex and somewhat straight in the middle, ends more or less abruptly constricted and rostrate. Raphe somewhat excentric, subarcuate with central pores small and terminal fissures directed towards the dorsal side. Axial area narrowly lanceolate; central area fairly large, more or less circular and dilated on the dorsal side. Striae 12—13 in 10 μ, regularly disposed, indistinctly punctate, radial throughout and 2—3 middle striae on the dorsal side abbreviated.

This species resembles *C. cuspidata* KÜTZ. (SCHMIDT, A., Atlas Diat., 1874—1944, t. 9, f. 50, 53—55; t. 374, f. 13—14; HUSTEDT, Bacil., 1930. 357, f. 650; VOIGT, genre Cymbella, 1943, 17, pl. 1, f. 15; CLEVE-EULER, A., Diat. Schwed. Finn.—IV, 1955, 146, f. 1217 a—d; FOGED, N., Diat. Pearyland, 1955, 64, pl. 10, f. 5), in the outline, rostrate apices and large central area. However, it differs from it in dimensions, uniformly set striae and 2—3 abbreviated mid-dorsal side striae. In its determination same amount of difficulties are experienced as by FOGED, yet it has not become possible here to come to any satisfactory conclusion. While considering *C. hybrida* GRUN. (SCHMIDT, op. cit., t. 377, f. 21—23; HUSTEDT, Bacil., 357, f. 652), the present form differs in having excentric raphe, more uniformly convex dorsal side, not very straight ventral side and different length to breadth proportions. The differences here are such that they do not permit satisfactory comparision and reference to any other similar looking species. It is, therefore, tentatively considered to be a new species.

This species was collected from various streams, water veins seeping out from hilly inclines and some cisterns, in smaller or larger numbers. It occurred more or less as a constant form in the locality but it was usually more frequent during November to December—January. A fairly distributed type. Type slide Pan. 13 : 148.

50. *Cymbella ventricosa* Kütz.

Hustedt, Bacil., 1930, 359, f. 661:—Length 24—28 μ, breadth 6.6 μ and striae 12—16 in 10μ.

This species occurred as a common form throughout the region but often in small numbers. A constant form for all seasons.

51. *Gomphonema sphaerophorum* Ehr.

Hustedt, Bacil., 1930, 372, f. 695:—Length 26.5—32 μ, breadth 7.5—8 μ and striae 14—16 in 10 μ.

This species was seen during different seasons but usually in small numbers, inhabiting slimy or brownish masses of matter loosely lying in tanks, cisterns and pools. It was stray in samples collected from water coarses and streams. A common form in the region.

52. *Gomphonema parvulum* (Kütz.) Grun. (Fig. 76 a—b)

Schmidt, A., Atlas Diat., 1874—1944, t. 234, f. 13—14 in particular; Van Heurck, Treat. Diat., 1896, 272, pl. 7, f. 306; Schönfeldt, Bacil., 1913, 124, f. 270; Venkataraman, G., S. I. Diat., 1939, 345, f. 126—128 (= *G. sphaerophorum* f. *subcapitata* f. nov. Venkat.) :—Length 23.—30 μ, breadth 6.5—7.2 μ and striae 13—15 or —16 in 10 μ.

While determining this species, attention was drawn to Venkataraman's *G. sphaerophorum* f. *subcapitata* f. nov., and it therefore required reexamination of the material. From the careful observations, it appeared that Venkataraman's specimen fits well with *G. parvulum*, in all respects. The remarks set by the author while creating his form as a new form of *G. sphaerophorum*, appear hardly convincing. The figures 126—128, given by the author, indicate different phases of *G. parvulum* which are already known in the literature. From my many years of extensive collections and observations, I have observed this and other phases of *G. parvulum*, and I am convinced that Venkataraman's *G. sphaerophorum* f. *subcapitata* cannot be other than *G. parvulum* particularly when I refer to Schmidt's Atlas and other references hitherto given. At the best I would consider Venkataraman's fig. no. 126 typical of *G. parvulum* and figs. 127—8 something approaching *G. parvulum* v. *lagenula* (Grun.) Hust. (Hustedt, Diat. Albert Nat.-park, 1949, 119, t. 11, f. 8—10). Further, the figures given by the author do not show stigma in the unilaterally formed central area.

This species was collected from all kinds of wet situations in the region and during all seasons. It was a common form more abundantly formed in brownish masses of matter but also sometimes as an epiphyte on *Oedogonium* sp. and other larger aquatic plants. Its

period of prolific growth appeared to be September to November. A common type.

53. *Gomphonema parvulum* v. *exilissima* GRUN. (Fig. 77)

HUSTEDT, Bacil., 1930, 373; CLEVE-EULER, A., Diat. Schwed. Finn. —IV, 1955, 178, f. 1269 d—f (= v. *exilissimum*):—Valves 26—28 μ long and 6—6.2 μ broad, narrowly lanceolate-clavate with apex clearly constricted and produced beak-like. Striae 13—16 in 10 μ, radial. In all other features like the type.

This diatom was mostly found with the type usually in smaller numbers. It occurred particularly in pools and cisterns. Elsewhere in the locality rather seen as a stray form.

54. *Gomphonema lanceolatum* EHR.

HUSTEDT, Bacil., 1930, 376, f. 700:—Length 38—40 μ, breadth 7—7.5 μ and striae 12—13 in 10 μ.

This species was noted to be common in the region since it was found in all wet situations and during different parts of the year. However, it was never gregarious. Its period of prolific growth was noted from September to December.

55. *Gomphonema gracile* EHR.

HUSTEDT, Bacil., 1930, 376, f. 702:—Length 40—48.3 μ, breadth 7.6—8 μ and striae 8—14 in 10 μ.

This species was seen usually in very small numbers during different seasons. However, it appeared as a constant form in various pools, ditches and cisterns. In tanks it was more frequent. A fairly distributed and common type.

56. *Epithemia zebra* (EHR.) KÜTZ.

HUSTEDT, Bacil., 1930, 384, f. 729:—Length 32—40 μ, breadth 7—7.5 μ, costae 2—4 in 10 μ and rows of alveoli 12—13 in 10 μ.

This species occurred as a very stray form in the locality. It was found to inhabit brownish slimy matter in cisterns, pools and certain water courses. Not at all a constant form. Rare in the region.

57. *Rhopalodia gibba* (EHR.) O. MÜLL.

HUSTEDT, Bacil., 1930, 390, f. 740:—Length 60—80 μ, breadth in girdle view 22—24 μ, costae 6—8 in 10 μ and rows of alveoli 13—14 in 10 μ.

This species usually occurred in smaller numbers in tanks and some cisterns around the hills but was very irregularly collected from other bodies of water. It was found to inhabit masses of dead vegetable matter as well as known to be epiphytic on *Chara*, *Ceratophyllum* or *Hydrilla*. Not common in the locality.

58. *Rhopalodia gibba* v. *ventricosa* (EHR.) GRUN.

HUSTEDT, Bacil., 1930, 391, f. 741:—Length 38—40 μ, breadth in girdle view 18—19 μ, costae 6—7 in 10 μ and rows of alveoli 13—14 in 10 μ.

This diatom was also represented in small numbers during different seasons. It was particularly found to inhabit marginal slime of pools and ditches. In tanks fairly more common.

59. *Hantzschia amphioxys* (EHR.) GRUN. v. *compacta* HUST. (Fig. 78—79)

SCHMIDT, A., Atlas Diat., 1874—1944, t. 345, f. 11—12; CLEVE-EULER, A., Diat. Schwed. Finn.—V, 1952, 48, f. 1419 g:—Valves 50—60 μ long and 9—9.5 μ broad, linear, weakly arcuate with constricted, somewhat produced capitate-rounded ends. Keel excentric, keel punctae 7—8 in 10 μ, quite clear. Striae 18—20 in 10 μ.

This species was collected in small to good number, mostly from pools, cisterns and some slowly flowing water courses in the region. It was found to inhabit pale brownish matrix. A good number of specimens were also collected from an over-flowing well on the hill top. However, not well distributed.

60. *Hantzschia amphioxys* v. *densestriata* (FONT.) A. CL. (Fig. 80)

CLEVE-EULER, A., Diat. Schwed. Finn.—V, 1952, 49, f. 1419 n—p:—Length 43.7—50 μ, breadth 6—6.6 μ, keel punctae 9—11 in 10 μ very small and striae 20—24 in 10 μ, fine.

This diatom was represented as a stray specimen in some cisterns. It occurred in brownish matter formed by decaying vegetable stuff. Rather rare in the locality.

61. *Hantzschia amphioxys* v. *gracilis* HUST. (Fig. 81)

SCHMIDT, A., Atlas Diat., 1874—1944, t. 329, f. 6—8; CLEVE-EULER, A., Diat. Schwed. Finn.—V, 52, f. 1421 i (= *H. gracilis* HUST.):—Valves 115—130 μ long and 10.2—10.5 μ broad, linear with almost parallel sides, fairly arcuate with wedge-shaped, produced, subcapitate rounded ends. Raphe part apparent at the poles. Keel excentric with keel punctae coarse, 7—8 in 10 μ, middle punctae distantly set. Striae 16—18 in 10 μ, finely punctate.

This diatom was found in slowly flowing water courses, in an overflowing well and some cisterns. It occurred usually in very small number during different times in the year. Not quite regularly collected. A sparsely distributed type in the area.

62. *Nitzschia tryblionella* HANTZ. v. *victoriae* GRUN.

HUSTEDT, Bacil., 1930, 399, f. 758:—Length 30—45 μ, breadth 15—20 μ, keel punctae 4—5—6 in 10 μ and striae 6—7 in 10 μ.

This diatom was found to be a widespread species in water courses, hill streams and water veins seeping out from hilly inclines. However, it was never found in any abundance. An all season form in the locality.

63. *Nitzschia palea* (Kütz) W. Sm.

Hustedt, Bacil., 1930, 416, f. 801:—Length 20—35 μ, breadth 2.5—3.5 μ, keel punctae 10—12 in 10 μ and striae about 35 in 10 μ.

This species was found in all wet situations on and around the hills. It occurred in brownish masses of dead vegetable matter or forming thin films on moist soils, rocks and the like. It was sometimes gregarious on moist soils or in marginal slime of some pools. A very common type.

64. *Nitzschia pseudofonticola* Hust. (Fig. 82)

Hustedt, Diat.-fl. Weser, 1957, 353, f. 83—90:—Valves 28.5—32 μ long and 4—4.2 μ broad, lanceolate with constricted capitate ends. Keel excentric with keel punctae 10—11 in 10 μ, very small. Striae possibly 35 in 10 μ, quite indistinct.

This species was collected as a very stray form in some pools, ditches and cisterns but in clusters of wet mosses it occurred fairly. Not common.

65. *Nitzschia clausii* Hantz. (Fig. 83)

Hustedt, Bacil., 1930, 421, f. 814:—Valves 27—31.5 μ long and 3.5—3.8 μ broad, linear, somewhat sigmoid at the ends which are constricted and obliquely wedge-shaped and capitate. Keel very excentric, sigmoid with keel punctae 12—13 in 10 μ, small and beaded. Striae over 30 in 10 μ, very fine and almost indistinct.

This species was collected mostly from cisterns and was found inhabiting the decaying vegetable stuff. It was also collected in small numbers from some pools and wet soils along with species of *Frustulia*. Not common. Probably an all season form.

66. *Surirella tenera* Greg.

Hustedt, Bacil., 1930, 438, f. 853:—Length 108.5—120 μ, breadth 30—33 μ and costae 18—20 in 100 μ.

This species was collected usually in small numbers from various water courses and streams in the region. It seldom occurred in standing water. An all-season form, but was seen to be more abundant during the period December to January. Not very common.

67. *Surirella subsalsa* W. Sm. (Figs. 84—86)

Cleve-Euler, A., Diat. Schwed Finn.—V, 1952, 105, f. 1526 a—d,

f :— Length 31.7—42.8 μ, breadth 8.7—13.8 μ and costae 40—50 in 100 μ.

This species was collected from several streams and water courses on and around the hills, but seldom in standing waters. It usually occurred in brownish masses of matter or tufts of wet mosses on sides of hills. A fairly common form in the locality. This form seems to be a variable one as it showed different phases during the same or different seasons in collections made from more or less same spots or other similar places. Of the variations noted, three different typical illustrations are given which were found to be inter-connected by several other intermediates. Some of these intermediates agreed with those accounted in my previous papers on the Jog-falls (1957) and Hirebhasgar (1958) diatoms.

68. *Surirella apiculata* W. SMITH (Figs. 87—88)

SCHMIDT, A., Atlas Diat., 1874—1944, t. 23, f. 34:—Valves 26.5—30 μ long and 7.5—8.5 μ broad, linear with or without slightly convex or concave sides, isopolar to indistinctly heteropolar with cuneate more or less constricted slightly to well marked produced or rostrate ends. Pseudoraphe very narrow. Flap margin very narrow with indistinct flap projections. Costae 6—8 in 10 μ, rib-like alternating with fine but clear striae, ribs do not reach the axial part. Striae 20—24 in 10 μ, fine but well marked.

While going through the literature, there appears to prevail quite an amount of uncertainty regarding the identity of this species. The two sets of illustrations in SCHMIDT'S Atlas appear to differ from each other, but, „t. 23, f. 34", more or less agrees well here.

HUSTEDT makes mention of *S. apiculata* W. SM. (HUSTEDT, Algenfl. Bremen—IV, 1911, 310, t. 3, f. 23; Bacil. Sudeten, 1914, 190, citing in both cases SCHMIDT'S Atlas, t. 23, f. 34—5, while in the latter case *S. lapponica* A. CL., being considered as synonym), in the first reference the given illustration does not correspond with the one given in SCHMIDT'S Atlas in as much as that the apices are not shown to be constricted and more or less produced. In the latter reference, in addition, another form *S. lapponica* A. CL., is considered as synonym of *S. apiculata*. While, CLEVE-EULER in order to re-establish *S. lapponica* (CLEVE-EULER, A., Diat. Schwed. Finn.—V, 1952, 118, f. 1558 a—b), includes not only HUSTEDT'S *S. apiculata* (as per citation) but also another species *S. gracilis* (W. SM.) GRUN. From the discussion that follows *S. lapponica* A. CL., it appears that the identity of W. SMITH'S original form (SCHMIDT'S Atlas, t. 23, f. 34) probably is not established. However, CLEVE-EULER seems to include probably SMITH'S form also under *S. lapponica* by giving „f. 1558 d".

Further, VAN HEURCK gives *S. ovalis* BRÉB. v. *pinnata* (W. SM.) V. H. (VAN HEURCK, Treat. Diat., 1896, 373, pl. 13, f. 591) and describes, „Valve linear, narrow with cuneate apices, length 40—50 μ", and finally remarks, „all these forms, which connect with one another, cannot be specifically separated". This form has very close resemblance with the present specimens as well as with *S. apiculata* of SCHMIDT's Atlas.

Again, TIFFANY and BRITTON describe *S. apiculata* W. SM. (TIFFANY & BRITTON, Alg. Illinois, 1952, pl. 78, f. 913), by giving two figures and bring out in relief the costae short and long alternating—but this fact does not appear to be so in SCHMIDT's Atlas from which these authors seemed to have adopted the same. However, their statement, „an imperfectly known species", is valuable.

With these references before me and the present material of which I depict „figs. 87—88" showing the maximum divergence noted among specimens from the area collected during different seasons and years, from the same or similar habitats, I am at the best inclined to mark out my specimens for *S. apiculata* W. SM. (SCHMIDT's Atlas, t. 23, f. 34 only). And, I further propose to consider VAN HEURCK's *S. ovalis* BRÉB. v. *pinnata* (W. SM.) V. H. und CLEVE-EULER's *S. lapponica* v. *genuina* A. CL. „fig. 1558 b?, d," under *S. apiculata*.

This species was collected from several wet situations in the area in varying amounts. It was found to inhabit brownish masses of matter as well as encrustations formed by some Myxophyta in cisterns. A set of samples from an over-flowing well and a water course in a garden near Teen-darwaja yielded it in good numbers in 1954. This species was more frequently noted during October to December. A more or less constant and common type in the region.

SUMMARY

For the first time the Diatom flora of Panhalgarh-Hills in the District of Kolhapur was investigated of which an illustrated account is presented in these pages. In this account, an attempt also is made to give general notes on their occurrence, distribution in the region, seasonal variation and frequency. With certain diatoms some life-history features are also indicated.

In all sixty-eight diatoms are recorded from the area after a consistant collection work and study for a period of about three-and-half years. Of these, 23 are new records for India and eight species, five varieties and one form, tentatively, are considered to be new for Science.

The material in connection with the present study lies in the author's own herbarium. The type-slide numbers pertaining to new taxa are indicated in the text.

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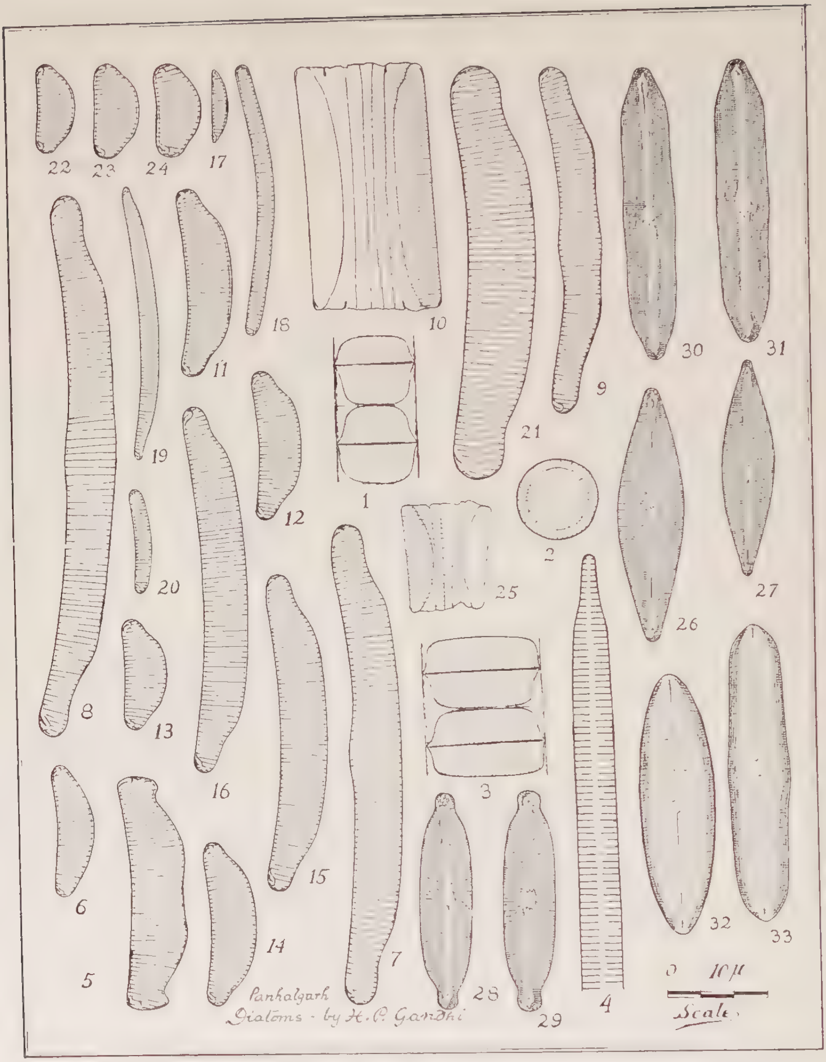

PLATE I

Fig. 1—3. *Melosira dickiei* (THW.) KÜTZ. - 4. *Synedra ulna* (NITZ.) EHR. f. *staurodestituta* PANT. - 5. *Eunotia praerupta* EHR. v. *bidens* GRUN. - 6. *E. pectinalis* (KÜTZ.) RABH. v. *curta* V. H. - 7. *E.* - v. *ventralis* (EHR.) HUST. - 8. *E.* - v. *gibbulosus* VENKAT. - 9. *E.* - v. *neglecta* GANDHI. - 10—16. *E. rostellata* HUST. - 17. *E. veneris* (KÜTZ.) O. MÜLL. - 18. *E. lunaris* (EHR.) GRUN. - 19. *E. alpina* (NAEG.) HUST. - 20 *E. pseudoparallela* Å. BERG v. *densestriata* A. CL. - 21. *E. hebridica* Å. BERG v. *bergii* v. nov. - 22—25. *E. tumida* sp. nov. - 26—27. *Frustulia saxonica* RABH. - 28—29. *F. vulgaris* THW. v. *subcapitata* v. nov. - 30—31. *F. indica* sp. nov. - 32. *Neidium amphigomphus* (EHR.) CL. v. *obtusum* A. CL. - 33. *N. panhalgarhensis* sp. nov.

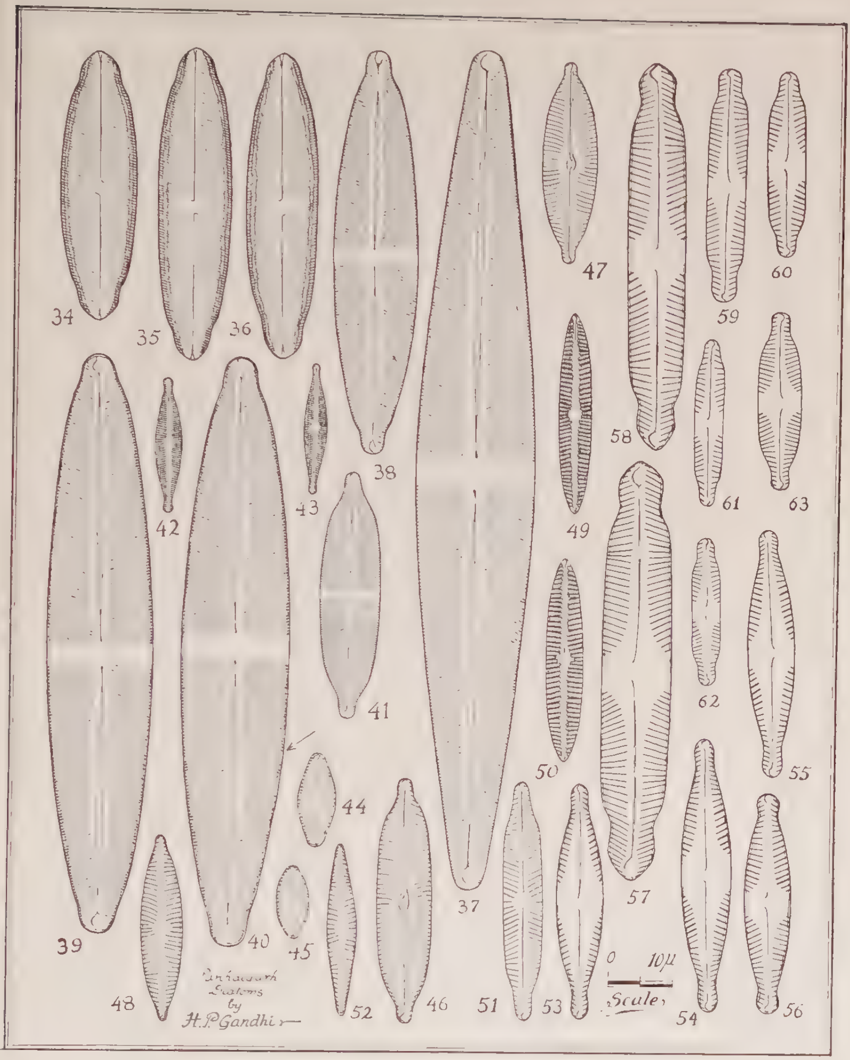

PLATE II

Fig. 34—36. *Neidium obliquestriatum* A. S. v. *rostrata* Skv. - 37. *Stauroneis phoenicenteron* Ehr. f. *gracilis* Dip. - 38—40. *S.* - f. *producta* Gandhi (f. 40 - arrow shows defective structure) 41. *S. anceps* Ehr. v. *linearis* (Kütz.) V. H. - 42—43. *Anomoeoneis exilis* (Kütz.) Cl. - 44—45. *Navicula mutica* Kütz. - 46. *N. viriduloides* sp. nov. - 47. *N.* - v. *lanceolata* sp. et v. nov. - 48. *N. zanoni* Hust. - 49—50. *N. venezuelensis* Hust. - 51. *N. panhalgarhensis* sp. nov. - 52. *N. radiosa* Kütz. v. *minutissima* (Grun.) Cl. - 53—56. *Pinnularia braunii* (Grun.) Cl. - 57—58. *P. conica* Gandhi. - 59—62. *P. pusilla* sp. nov. - 63. *P. interrupta* W. Sm. f. *minor* B. Pet.

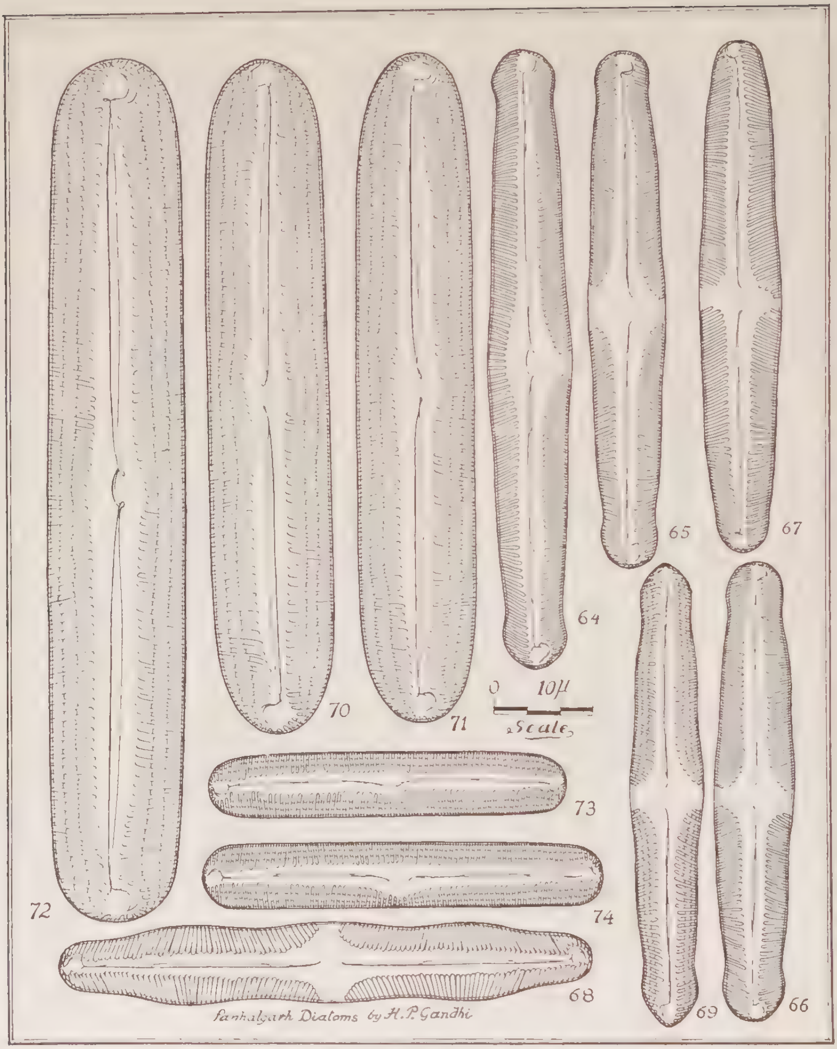

PLATE III

Fig. 64—66. *Pinnularia panhalgarhensis* sp. nov. - 67. *P.* - v. *lanceolata* sp. et v. nov. 68. *P. legumen* Ehr. v. *interrupta* v. nov. 69. *P. esox* Ehr. v. *capitata* Gandhi - 70—72. *P. major* (Kütz.) Cl. v. *linearis* Cl. - 73—74. *P. sudetica* Hilse v. *commutata* (Grun.) Cl. f. *obtusata* f. nov.

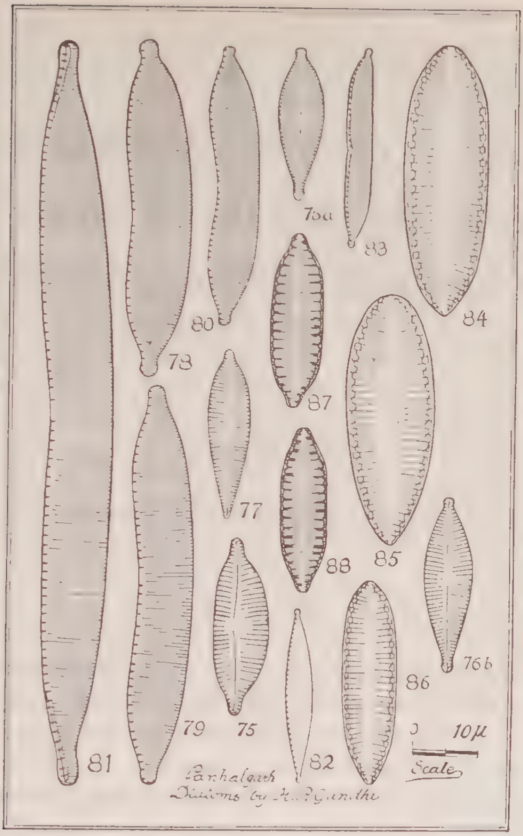

PLATE IV

Fig. 75. *Cymbella pseudocuspidata* sp. nov. - 76 a—b. *Gomphonema parvulum* (KÜTZ.) GRUN. - 77. *G.* - v. *exilissima* GRUN. - 78—79. *Hantzschia amphioxys* (EHR.) GRUN. v. *compacta* HUST. - 80. *H.* - v. *densestriata* (FONT.) A. CL. - 81. *H.* - v. *gracilis* HUST. - 82. *Nitzschia pseudofonticola* HUST. - 83. *N. clausii* HANTZ. - 84—86. *Surirella subsalsa* W. SM. - 87—88. *S. apiculata* W. SMITH.

Notes on the Diatomaceae from Ahmedabad and its environs - II

On the Diatomflora of Fontain-reservoirs of the Victoria Garden

by

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SYNOPSIS

In these notes the Diatom community of fountain-reservoirs of the Victoria garden is systematically examined and some remarks on their ecology, occurrence and distribution are given. From the observations and the halobion data available, due to extensive and valuable researches done by Hustedt, Petersen, Foged and others, it is concluded here from the occurrence of Diatom-floral types that the water of these reservoirs have a high chloride-contents. This fact is also corroborated from the water-analysis-data available from the Asstt. Officer-in-charge Public Health Laboratory, Municipal Corporation, Ahmedabad.

INTRODUCTION

This paper deals with the Diatom-flora collected from fountain-reservoirs of the Victoria Garden of which the water is periodically changed. Due to this periodic change of water the planktonic diatom-element does not find hold and therefore is sparsely represented. But on the other hand a plastic community thrives well, particularly the one which is capable of forming slimy films or encrustations on the walls of the reservoirs. This fact was adduced from an observation made for a period of six months (i.e. June 1957 to December 1957), by noting conditions of the fountain-reservoirs once a week and drawing samples therefrom fortnightly.

This material was mostly collected by scraping the surface coating of inside-walls of reservoirs and in the form of floating flakes of green-matter. This way several samples were collected and examined periodically at the Biology Laboratory of the Gujarat College, despite of several difficulties.

Of the material observed, a rough count of Diatom species was carried out and the rise and fall in the frequency of individual forms was estimated from month to month for the period stated above, of which the record is given in the following.

Besides these collections, several others were made from various wet situations in and around the city of Ahmedabad as indicated in my previous paper (in press), and in this event some notes on occurrence and distribution of these diatoms, confined to this region only, are given. The positions of these diatoms in the halobion system are also considered in accordance with celebrated works of HUSTEDT, PETERSEN, FOGED and others and also with certain local observations and frequency counts. Of some of the new forms, the halobion rate is tentatively fixed in the light of the data of Chemical Analysis of water available through the kind office of Asstt. Officer-in-charge Public Health Laboratory, Municipal Corporation, Ahmedabad. The author's thanks are due to the Officer concerned. The following is the range of data available of Chemical Analysis of water which is supplied to this area from Raikhad Tube-well:

pH	7.8—8
NaCl	39—42 parts per 1,00,000
Hardness - Permanent	0.2
Temporary	17—19
$CaSO_4$	0.2

At the end of this paper Halobion Spectrum is presented from which the conclusion is drawn that the water supply to this area is more or less brackish.

Further, several illustrations are given of individual diatoms, at least in some cases, to indicate their changes of forms due to their multiplication in their natural habitats. These changes may be referred to their life-history features or reproductive phases. However, the auxospore formation or post-auxospore forms which result in production of abnormal frustules, were not observed. But, whatever frustules or valves seen, they were nature and perfect or rarely with slight aberrations in their markings as are recorded by VOIGT (1955) and other workers in cases of other diatoms.

In all 28 diatoms are recorded from this locality of which six are new records for India and three species are considered to be new

for Science. The material in connection with this paper lies in the personal herbarium of the author.

Again to be concise, all the descriptions and illustrations are avoided of such forms which are elsewhere recorded in the Indian literature unless the necessity was so felt for the departure. However, the dimensions are given as noted of specimens found here. Besides under individual specimens notes are also given on ecology, occurrence and distribution. All the remaining diatoms which make new records for India and for Science are fully described and illustrated.

1. *Cyclotella meneghiniana* KÜTZ.

HUSTEDT, Bacil., 1930, 100, f. 67:—Diameter 10—20 μ, striae 9—10 in 10 μ.

This diatom was found in a small number in the encrustations. Its number gradually increased till October whereafter it became a stray form. It is a widely distributed diatom in the region of Ahmedabad, sometimes becoming gregarious. Its position in the halobion system is .... Halophilous.

2. *Synedra ulna* (NITZ.) EHR.

HUSTEDT, Bacil., 1930, 151, f. 158—9:—Length 80—110 μ, breadth 5.6—6 μ and striae 9—10 in 10 μ.

This species was found in a small number in slimy films formed by *Ocillatoria* and also in floating flakes of green-matter. It was for the entire period of observation found to be constant except that a slight rise was seen in later part of September. It was noted as a common form throughout Ahmedabad, but found more abundantly in larger bodies of water. Its place in the halobion system is .... Indifferent.

3. *Achnanthes exigua* GRUN.

HUSTEDT, Bacil., 1930, 201, f. 286:—Length 10—19 μ, breadth 4.2—6 μ and striae 22—26 in 10 μ.

This species was found thriving well in slimy encrustations among the members of Myxophyta. It appeared as a stray form in early July but by the end of August-September it increased well in number and stayed in this condition till November. After this period a slight decline was noted. This species was also noted to form slimy films on submerged leaves. Elsewhere in Ahmedabad it was noted in similar habitats as well as in marginal slime of road-side pools and puddles. It was rarely gregarious. Its position in the halobion system is .... Indifferent.

4. *Diploneis subovalis* CLEVE.

VENKATARAMAN, G., Some S. I. Diat., 1939, 322, f. 74, pl. 17, f.

3—4:—Length 29—30 μ, breadth 18 μ, costae 9—11 in 10 μ, alternating with double rows of alveoli.

This diatom was found as a very stray form in the encrustation and it occurred only in a few samples. Nothing can be said regarding its frequency, except that it was collected particularly during the months of October-November. From other places in this region it was collected from Chandola and Kankaria lakes in a smaller number. It is a rare form with a very limited distribution. Its place in the halobion system is .... ?

5. *Anomoeoneis sphaerophora* (Kütz.) Pfit. (Figs. 1—2)

Hustedt, Bacil., 1930, 262, f. 422:—Length 45—64 μ, breadth 13—20 μ and striae 16—18 in 10 μ. Of this species two illustrations are given, one of the smallest and other of the largest form that occurred in the collection. On close comparison of these, it appears that they do not show any difference either in their outline or the structure.

This species was found abundantly growing in encrustations of the reservoirs. It first occurred fairly in months of July-September and then gradually increased till the middle of November and was constant till January 1958. After this time no observation could be made on account of author's unfortunate transfer from the place. This diatom was noted to be a widespread species in Ahmedabad since 80 % of the total collections contained it in smaller or larger numbers. It was sometimes noted to be gregarious in certain reservoirs and pools in the Sabermati river bed. In the present habitat it was a subdominent type. Its place in the halobion system is .... Halophilous.

6. *Anomoeoneis sculpta* (Ehr.) Cl. (Figs. 3—8, 18)

Cleve-Euler, A., Diat. Schwed. Finn.—III, 202, f. 927 a—b; Hendey, N. I., Littoral Diat., 1951, 56, pl. 17, f. 16:—Length 20—68 μ, breadth 12—18 μ and striae 16—20 in 10 μ. Of this species seven illustrations are given to show that larger forms are linear-lanceolate or linear-elliptical and this outline is gradually lost in smaller specimens which appear then broadly lanceolate ofcourse with produced rounded ends. In still smaller forms measuring less than 35 μ, as depicted in figs. 6—8, another type of deviation is believed to have taken place. This deviation affected the apices in such a way that they became slightly constricted to appear subrostrate instead of clearly rostrate-rounded. Moreover, these smaller forms could not be considered even as varietal taxa for between all these typical illustrations intermediate gradations were found to exist. In the following table typical dimensions are given, as noted for the said species:

Length:	Breadth:	Striae in 10 μ
20 μ	12 μ	18—19
20.5 μ	12.3 μ	20
23 μ	12.7 μ	18
28.5 μ	12.5 μ	18
28.5 μ	13 μ	20
35 μ	14.2 μ	18—19
38 μ	14.2 μ	18
40 μ	14 μ	16—18
45 μ	14.5 μ	18—20
48 μ	17 μ	16—18
49 μ	15.7 μ	17
64 μ	18 μ	18—19
68 μ	18 μ	18

This diatom was found in encrustation with *A. sphaerophora* (KÜTZ.) PFIT., and was more abundant and distinctly dominant over all other diatoms. It was found to form an association with *A. sphaerophora*, *A. lanceolata* sp. nov. and *Navicula pygmaea* KÜTZ. It was seen right from the month of June 1957, when the observation was undertaken, in a good number and as a dominant form. Its peak period was noted to be from late October to November. After this peak value reached, it continued thus till middle of January 1958 whereafter no observations could be made. Elsewhere in Ahmedabad, it occurred rather sparingly or as a stray form but in certain pools in the Sabermati river bed it was noted in varying amounts and seldom gregariously. In all about 70 % of samples collected from the said region contained it. Its position in the halobion system is .... ?

7. *Anomoeoneis lanceolata* sp. nov. (Figs. 9—10)

Valvae 50—67 μ longae atque 15—18 μ latae, plus minus lanceolatae cum apicibus producto-rotundatis. Raphe tenuis et recta, ornata poris distincte centralibus cum aliquantum hamo-simile, fissuris terminalibus curvatis. Area axialis angustissima, linearis; area centralis fere ampla, rectangularis ac unilateraliter dilatata. Striae 18—19 in 10 μ, distincte punctatae, radiales in medio atque aliquantum convergentes in utroque apice, pluribus sulcis longitudinalibus, hyalinis, irregulariter decussatis ad partem axialem.

Valves 50—67 μ long and 15—18 μ broad, more or less lanceolate with produced rounded ends. Raphe thin and straight with central pores distinct, somewhat hook-like and terminal fissures curved. Axial area very narrow, linear; central area fairly wide, rectangular

and unilaterally expanded. Striae 18—19 in 10 μ, distinctly punctate, radial in the middle and convergent towards the ends, crossed by many longitudinal hyaline irregular bands towards the axial area.

This species appears to be a distinctive one with regards to its outline and the arrangement of striae towards the apices where they become convergent. Moreover, the central area is fairly wide and unilaterally rectangular. Of this species several specimens were observed in the collections. They showed some range of variations in the outline from a broadly lanceolate pattern—something similar to that of *A. sculpta* (EHR.) CL., to distinctly lanceolate shape. However, the convergent striae present towards the apices make it a distinctive species. Type slide Ahm. 6: V 352.

This diatom occurred in clusters of *A. sphaerophora*, *A. sculpta* and *Navicula pygmaea* KÜTZ., in a good number. In early days of July it was only casually observed but by late October it became fairly common with other species of *Anomoeoneis*. However, it was never quite abundant. By the end of November it began to decline rather rapidly and when the last sample was drawn from the reservoir in January 1958, it was seen only in a small number. From other parts of Ahmedabad, this species was only casually collected and particularly from the Sabermati river bed and Seth Sarabhai's garden reservoirs. Its place in the halobion system is . . . . ?

8. *Navicula rhombiformis* sp. nov. (Figs. 11—20, 20)

Valvae 76—105 μ longae atque 24—28.5 μ latae, rhombeo vel rhombeo-lanceolatae, apicibus fere abrupte constrictis atque producto rotundatis sed haud capitatis. Raphe tenuis et recta, ornata poris centralibus distincte unilateraliter inclinatis. Area axialis angustissima, area centralis indistincta. Striae 16—18 in 10 μ, aliquantum radiales cum lineis aeque distantibus, tenues ac indistincte punctatae, striae longitudinalibus indistinctae.

Valves 76—105 μ long and 24—28.5 μ broad, rhombic to rhombic-lanceolate with somewhat abruptly constricted, produced rounded ends but not at all capitate. Raphe thin and straight with central pores clearly unilaterally inclined. Axial area very narrow; central area indistinct. Striae 16—18 in 10 μ, weakly radial, fine and indistinctly punctate, longitudinal striae indistinct.

This species resembles *Navicula cuspidata* KÜTZ. v. *ambigua* (EHR.) CL. (HUSTEDT, Bacil., 1930, 268, f. 434; SCHMIDT, A., Atlas Diat., 1874—1944, Taf. 211, f. 42—47 (*N. ambigua* W. SM.)), somewhat in the outline, constricted and produced rounded apices. However, the present species differs in having strongly rhombic outline, gradually tapering apices which are not at all capitate as indicated in works cited above. Moreover, the longitudinal striae are undiscernible. It

is, therefore, regarded as a new species. Type slide Ahm 1. v 353

Of his diatom quite many specimens were recorded in association with *Anomoeoneis sphaerophora* (Kütz.) Pfit., *A. sculpta* (Ehr.) Cl., *A. lanceolata* sp. nov. and *Navicula pygmaea* Kütz. These specimens were conspicuous for their large dimensions and rhombic outline. This species was first observed as a stray form in the month of July upto August 1957, but after this period it increased in good numbers till October, then it was noted as a constant form till January 1958. The samples collected from the Sabermati river bed showed its presence casually as was the case noted from Kankaria and Chandola lakes. Its place in the halobion system is . . . . ?

9. *Navicula pupula* Kütz.

Hustedt, Bacil., 1930, 281, f. 467 a:—Length 16—21.8 μ, breadth 7.6 μ and striae 18—20 in 10 μ.

This diatom was found along with its following variety as a constant form. It showed its slight increase in the month of September but soon declined to its original level. This species also was collected from several wet situations in and around Ahmedabad suggesting its very wide distribution. However, it was never found to be gregarious. Its place in the halobion system is . . . . Indifferent.

10. *Navicula pupula* v. *capitata* Hust.

Hustedt, Bacil., 1930, 281, f. 467 c:—Length 24—28.5 μ, breadth 7.6—8 μ and striae 18—20 in 10 μ.

This diatom was somewhat more abundantly seen than the type. It varied in a similar way. From the other parts of Ahmedabad it was particularly found well flourishing in certain road-side pools and ditches formed during the rain. Its position in the halobion system is . . . . Indifferent.

11. *Navicula salinarum* Grun. v. *intermedia* (Grun.) Cl.

Cleve-Euler, A., Diat. Schwed. Finn.—III, 1953, 159, f. 820 b—c:—Length 30—34 μ, breadth 7.5 μ and striae 14—16 in 10 μ.

This species was found in a good number in encrustations of the reservoirs. It showed its slight increase during late October to November and remained as a constant form till January 1958 along with species of *Anomoeoneis*. It was also recorded from several places in Ahmedabad, but seldom seen in any abundance. Its place in the halobion system is . . . . ?

12. *Navicula pygmaea* Kütz. (figs. 21—22)

Hustedt, Bacil., 1930, 312, f. 561:—Length 16.5—26.6 μ, breadth 8.3—11.5 μ and striae about 26 in 10 μ.

This species was found quite abundantly as a dominant or sub-dominant member of the association. It was first observed in good numbers but by the end of July it began to increase till its peak period was late November or about the first week of December. It was also collected quite in numbers from the Sabermati river bed, Kankaria and Chandola lakes and in a small number from fountain reservoirs of Seth Sarabhai's garden. In all 35—40% of samples collected from parts of Ahmedabad contained it, suggesting its average distribution. Its place in the halobion system . . . Mesohalobous.

13. *Amphora veneta* KÜTZ.

HUSTEDT, Bacil., 1930, 345, f. 631:—Length 12—20 μ, breadth 8—12 μ in the girdle view and striae 22—26 in 10 μ, towards the ends.

This species was recorded in a small number in the encrustations. It remained as a constant form throughout the period of observation except once when a small rise was noted in month of December. It is a common diatom in the region of Ahmedabad, somewhat more frequent in pools and puddles on the road side inhabiting marginal scum. Its place in the halobion system is .... Indifferent.

14. *Cymbella ventricosa* KÜTZ.

HUSTEDT, Bacil., 1930, 359, f. 661:—Length 20—24 μ, breadth 7—8 μ and striae 12—15 in 10 μ.

This species was found as a stray form for the entire period of investigation. Some samples were barren of this diatom. Its distribution in Ahmedabad region is average. It more commonly occurred in roadside pools and ditches during the rainy seasons. Its place in the halobion system is .... Indifferent.

15. *Cymbella cymbiformis* (KÜTZ.) V. H. v. *jimboii* (PANT.) A. CL. (fig. 23)

CLEVE-EULER, A., Diat. Schwed. Finn.—IV, 1955, 160, f. 1246 g:—Length 50—60 μ, breadth 11—11.5 μ and striae 8—11 in 10 μ.

This diatom was also seen sparingly in encrustations of the reservoirs for most of the period. It was particularly noted in a fair number in months of November to December 1957. From other parts of Ahmedabad it was only represented in about 6—8% of samples. A few isolated cells were noted in samples from the Chandola lake. Its position in the halobion system is .... Indifferent.

16. *Nitzschia levidensis* (W. SM.) GRUN.

HUSTEDT, Diat. Fluss-System der Weser, 1957, 338; Bacil., 1930, 399, f. 760 (= *N. tryblionella* v. *levidensis*):—Length 35—46 μ,

breadth 8.4—9 μ, keel punctae 10—11 in 10 μ and striae 11—12 in 10 μ.

This diatom was found rather sparingly in encrustations of reservoirs for most of the period of observation but during the middle of October it was somewhat more frequent. However, it is a widespread diatom in the region of Ahmedabad, occurring in smaller or larger numbers. Its place in the halobion system is....... Halophilous.

17. *Nitzschia apiculata* (Greg.) Grun. (Figs. 24—25)

Hustedt, Bacil., 1930, 401, f. 765:—Valves 30—47.5 μ long and 6—8.5 μ broad, linear with distincty concave sides and subcuneate, constricted apiculate ends. Keel excentric with keel punctae small (9—10)? in 10 μ. Striae about 18—20 in 10 μ, crossed by a fairly conspicuous longitudinal space in middle with very fine scattered punctae.

This diatom was recorded both in the encrustations and floating flakes of green matter along with other diatoms. It was first seen in a small number from June to August 1957. thereafter it gradually increased till October. After this period it remained constant for a month and somewhat suddenly declined. It was very stray in the last sample drawn in January 1958. This diatom was also recorded from several such habitats, Chandola and Kankaria lakes and some pools in the Sabermati river bed. Its prolific growth was noted in fountain reservoirs of Seth Sarabhai's garden and Chandola lake. Its position in the halobion system is .... Mesohalobous.

18. *Nitzschia thermalis* Kütz. v. *minor* Hilse

Hustedt, Bacil., 1930, 403, f. 772:—length 35—46 μ, breadth 7.6—8 μ, keel punctae 9—10 in 10 μ and striae over 30 in 10 μ.

This diatom was found in fair numbers in the encrustations of reservoirs. It was more or less a constant form for most of the period except that it showed slight rises in number during August and November. It was noted as a common form in the region of Ahmedabad being observed in about 60 % of samples taken from a variety of wet situations. However, it was never found in gregarious formation. Its position in the halobion system is .... Indifferent.

19. *Nitzschia pseudofossilis* sp. nov. (Fig. 14)

Valvae 22—26 μ longae atque 4.7—5.4 μ latae, lineares, latera modice concava, apicibus cuneatis ac constrictis apiculatis. Carina valde ex-centro, carinae puncta 11—13 in 10 μ, minuta. Striae tenues, circiter 26 in 10 μ, indistincte punctatae.

Valves 22—26 μ long and 4.7—5.4 μ broad, linear with sides feebly concave, ends cuneate, constricted and apiculate. Keel strongly

excentric, keel punctae small, 11—13 in 10 μ. Striae fine, about 26 in 10 μ, indistinctly punctate.

This diatom resembles *N. diducta* HUST. (HUSTEDT, Diat. Sunda-Exped., 1937—9, 473, t. 40, f. 20), *N. umbilicata* HUST. (HUSTEDT, Diat. Albert Nat.-park, 1949, 129, t. 11, f. 65), *N. fossilis* (HUST. (HUSTEDT, Aërophile Diat., 1942, 70, f. 45), in the outline, apices and the small keel punctae. However, it differs from all of them with regard to dimensions, length to breadth proportions, number of keel punctae and striae. While comparing this with all others named above, the striae number approximate with that of *N. fossilis*, hence this species is considered nearer to it and named as *N. pseudofossilis* sp. nov. Type slide Ahm 8 : V 354.

This diatom was found in a small number for the entire period of investigation, except in the month of August when it was very rare. In other collections from Ahmedabad, it was noted only in a few samples—one obtained from fountain reservoirs of Seth Sarabhais's garden and other from Chandola and Kankaria lakes. A sparsely distributed form. Its place in the halobion system is ....?

20. *Nitzschia amphioxioides* HUST. (Fig. 15)

HUSTEDT, Diat. Albert Nat.-park, 1949, 140, t. 13, f. 65—72; Diat. Lago de Maracaibo, 1956, 126, f. 66:—Valves 17—24 μ long and 3.3—3.7 μ broad, linear with distinctly concave sides and wedge-shaped, constricted rostrate ends. Keel excentric with keel punctae clearly beaded and coarse 12 in 10 μ. Striae 24—26 in 10 μ.

This diatom occurred in association of *Anomoeoneis sphaerophora* (KÜTZ.) PFIT. and others, in the encrustations. It appeared as a constant form and usually in a small number. It showed its slight increase in October—November, whereafter it gradually declined in number to appear as a stray form. It was also collected from similar situations as well as from Chandola and Kankaria lakes. In the Chandola lake it appeared as a common form particularly on spots where more organic matter was present. In all only 25% of samples contained it. Its place in the halobion system is .... Indifferent?

21. *Nitzschia calida* GRUN. (Fig. 16)

CLEVE-EULER, A., Diat. Schwed. Finn.—V, 1952, 62, f. 1439 a—b:—Valves 33.4—36 μ long and 9—9.2 μ broad, linear with broadly cuneate to subcuneate, constricted apiculate ends. Keel very excentric with keel punctae 10—11 in 10 μ, small. Striae 15—17 in 10 μ.

This species was found in a small number during October-November in the encrustations along with other diatoms. It was very rare

during June to August 1957 and same was the case in January 1958. In samples collected from other parts of Ahmedabad it was found to be fairly frequent in Chandola lake, Seth Sarabhai's garden reservoirs and some pools in the Sabermati river bed. It showed a restricted distribution. Its place in the halobion system is . . . . ?

22. *Nitzschia regula* Hust. v. *fennica* A. Cl. (Fig. 17)

Cleve-Euler, A., Diat. Schwed. Finn.—V. 1952, 82, f. 1487 c:—Valves 82—122 μ long and 7—7.5 μ broad, linear or slightly sublinear with somehwat abruptly narrowed, constricted, produced rounded beaklike ends. Keel very excentric with a slight constriction in the middle, keel punctae 6—8 in 10 μ, small, rounded and distinct. Striae about 28 in 10 μ.

This diatom was found in a fair number in the encrustations formed by some Myxophyta and species of *Anomoeoneis*. It was found as a constant species showing only a slight increase sometimes in November. It was also found in several collections from other parts of Ahmedabad but particularly in larger bodies of water or in fountain reservoirs of gardens. Its place in the halobion system is . . . . ?

23. *Nitzschia frickei* Hustedt (Fig. 18)

Schmidt, A., Atlas Diat., 1874—1944, t. 347, f. 8—10:—Valves 63—67 μ long and 8.5—8.7 μ broad, linear with cuneate to subcuneate constricted produced or subcapitate ends. Keel very excentric, keel punctae 8—10 in 10 μ, quite distinct and somewhat irregularly placed. Striae about 30 in 10 μ fine.

This diatom was found in a small number or as a stray form for the entire period of observation. It was somewhat more common during the middle of December. It also occurred in a few other samples from some parts of Ahmedabad, particularly in Chandola lake. Its distribution in the region was restricted. Its place in the halobion system is . . . . ?

24. *Nitzschia microcephala* Grun.

Hustedt, Bacil., 1930, 414, f. 791:—Length 8—14 μ, breadth 3 μ, keel punctae 12—13 in 10 μ and striae about 35 in 10 μ.

This species was found in a small number and as a constant form. It occurred both in the encrustations and in floating flakes of green-matter or some Myxophyta. It is a common diatom in the region of Ahmedabad. It was found more abundantly growing in marginal slime of Chandola lake, certain pools and ponds on the road sides. Its place in the halobion system is . . . . Indifferent.

25. *Nitzschia microcephala* v. *elegantula* GRUN.

VAN HEURCK, Treat. Diat., 1896, 402, pl. 17, f. 559:—Length 12—15 μ, breadth 2.8 μ, keel punctae 12—13 in 10 μ and striae 28—30 in 10 μ.

This diatom was commonly collected from the encrustations of reservoirs along with other species. In the month of August it occurred as a stray form and thereafter it gradually increased till October and remained constant. However, it was never in appreciable number. It was fairly common in samples drawn for the last occassion in January 1958. From other parts of Ahmedabad, it was collected from similar situations as well as from road-side pools, ditches, ponds and Chandola lake where it was found mixed up in rotting organic matter. In all about 40% of samples yielded it. Its place in the halobion system is .... ?

26. *Nitzschia amphibia* GRUN.

HUSTEDT, Bacil., 1930, 414, f. 793:—Length 16—22 μ, breadth 2.5—2.7 μ, keel punctae 10—12 in 10 μ and striae 16—18 in 10 μ.

This species was found as a constant form for the entire period of observation, except that only a small increase was noted in October. It is a widely distributed diatom in the region and seldom it was found gregariously. Its place in the halobion system is .... Indifferent.

27. *Nitzschia amphibia* v. *acutiuscula* GRUN.

CLEVE-EULER, A., Diat. Schwed. Finn.—V, 1952, 86, f. 1496 f—i: —Length 20—26 μ, breadth 4—4.2 μ, keel punctae 10 in 10 μ and striae 17—18 in 10 μ.

This diatom was found along with its type usually in smaller number or as a stray form. Fairly distributed in the region of Ahmedabad. Its place in the halobion system is .... Indifferent.

28. *Nitzschia terricola* J. W. G. LUND (Fig. 18)

LUND, J. W. G., Brit. Soil Algae, 1946, 100, f. 15 H—Q:—Length 25.5—35 μ, breadth 2.6—3.8 μ, valves linear with slightly concave sides and ends cuneate, constricted and produced or rostrate. Keel excentric, keel punctae 10—11 in 10 μ, coarse. Striae 24—26 in 10 μ distinct.

This diatoms was found in good number in the encrustations. It was first observed in July as a stray form but gradually it increased thereafter and by September end it was frequently noted till early November. After this period it began to decline and by December end no further observation could be made. This species was also recorded from other parts of the city in similar habitats and in some road-side

pools embedded in the organic waste. However, it was never seen in abundance. Its place in the halobion system is .... ?

From the examination of the Diatom-flora in light of Halobion rate that is determined by well known workers like HUSTEDT, PETERSEN, FOGED and others, the following is the Halobion Spectrum available:

THE HALOBION SPECTRUM

	Mesohalobous species recorded	... 2	which make		7.14 %
Oligohalobous	Halophilous ,, ,,	... 3	,,	,,	10.714 %
Oligohalobous	Indifferent ,, ,,	...11	,,	,,	39.286 %
Oligohalobous	Halophobous ,, ,,	...—	,,	,,	—
	? = undetermined species	...12	,,	,,	42.86 %
	number of Diatoms	28	,,	,,	100.000 %

From the above spectrum, it appears that the water of Victoria garden reservoirs has a tendency of being brackish as it supports a good percentage of salt loving forms whereas the Halophobous group has a negative distinction. This fact also seems to find support from results of Chemical analysis of water as indicated previously.

Of the 12 undetermined species of Diatoms indicated in the given spectrum, the following consideration may be made:

Anomoeoneis sculpta (EHR.) CL. may be regarded as a mesohalobous species, since it occurred abundantly as known from the observations and frequency counts. Moreover, its close association with well known species like *Navicula pygmaea* KÜTZ., *Nitzschia apiculata* (GREG.) GRUN. which are mesohalobous and its dominance over *Anomoeoneis sphaerophora* (KÜTZ.) PFIT., justify the fact.

Nitzschia microcephala v. *elegantula* GRUN. may also be regarded as a mesohalobous type, because it was elsewhere found to occur well in such situations which were ordinarily rich in organic-content. Moreover, CLEVE-EULER (1952) recorded it from marine water and VAN HEURCK (1896) from brackish-water.

Anomoeoneis lanceolata sp. nov., *Navicula rhombiformis* sp. nov., *N. salinarum* GRUN. v. *intermedia* (GRUN.) CL. and *Nitzschia amphioxioides* HUST. deserve to be placed in the halophilous group, since these species occurred in good numbers for the most period of observation. Again, they were found to form association with such species which required good NaCl-content.

For rest of the species nothing can be said at present, since data are scarce.

On account of these considerations the Halobion Spectrum given above becomes modified thus:

THE MODIFIED HALOBION SPECTRUM

	Mesohalobous species	 4	which	make	14.285 %
Oligohalobous	Halophilous ,,	 7	,,	,,	24.994 %
	Indifferent ,,	11	,,	,,	39.286 %
	Halophobous ,,	..........—	,,	,,	—
	? = undetermined,,	 6	,,	,,	21.425 %
					+ 0.010 %
		28	,,	,,	100.000 %

SUMMARY

In this paper an account is given of the Diatomflora of fountain-reservoirs of the Victoria gardens with notes on its ecology, occurrence and distribution. An attempt also is made to suggest the seasonal variation of the diatoms as could be noted for a period of six-months i.e. from June 1957 to January 1958. It appears from the results obtained, that, leaving some constant forms, most of the diatoms tended to be prolific during the period October to December.

At the end of the paper the Halobion Spectrum of the recorded diatoms is drawn on the basis of existing data. In the case of species of which the halobion-rate is not known, consideration is made, and some of the diatoms are tentatively given a position in the Halobion System. With this effect a modified spectrum is given.

In all twenty-eight diatoms are recorded from this locality. Of these six are new records for India and three species are considered to be new for the Science.

ACKNOWLEDGEMENT

The author wishes to express his grateful thanks to Drs. HUSTEDT, PETERSEN, FOGED, LUND, Mr. HENDEY, Mr. VOIGT and other friends for the generous offer of their published works which are used here.

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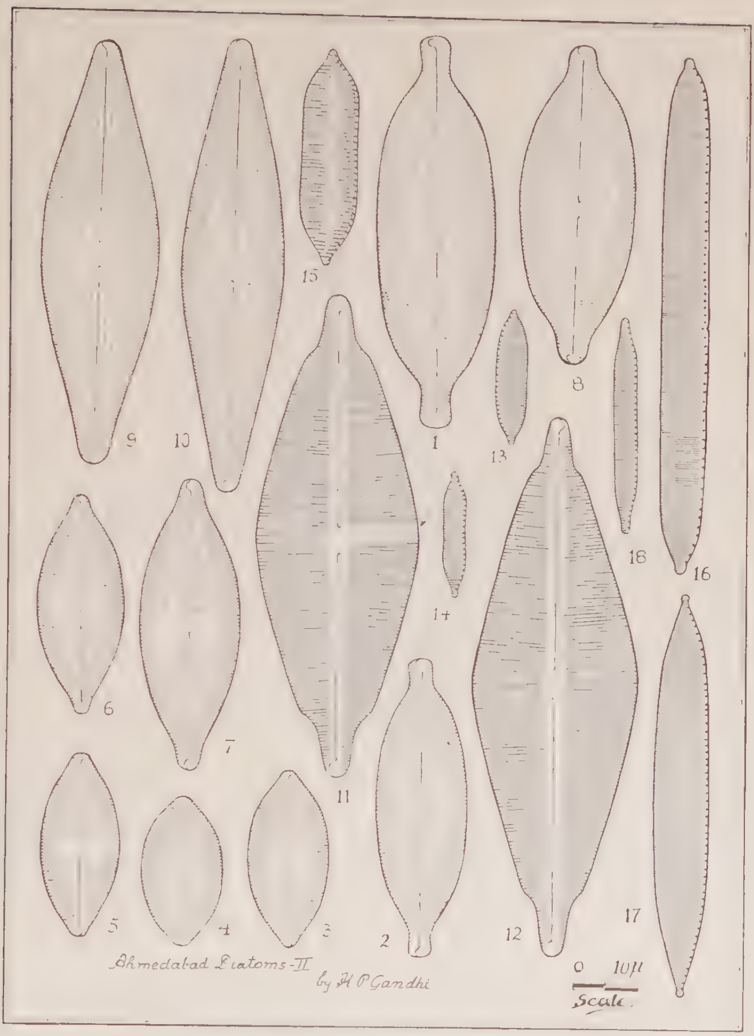

PLATE I

Fig. 1—2. *Anomoeoneis sphaerophora* (KÜTZ.) PFIT. - 3—8. *A. sculpta* (EHR.) CL. - 9—10. *A. lanceolata* sp. nov. - 11—12. *Navicula rhombiformis* sp. nov. (arrow shows the fine structure) - 13. *Nitzschia pseudofossilis* sp. nov. - 14. *N. amphioxioides* HUST. - 15. *N. calida* GRUN. - 16. *N. regula* HUST. v. *fennica* A. CL. - 17. *N. frickei* HUST. - 18. *N. terricola* J. W. G. LUND.

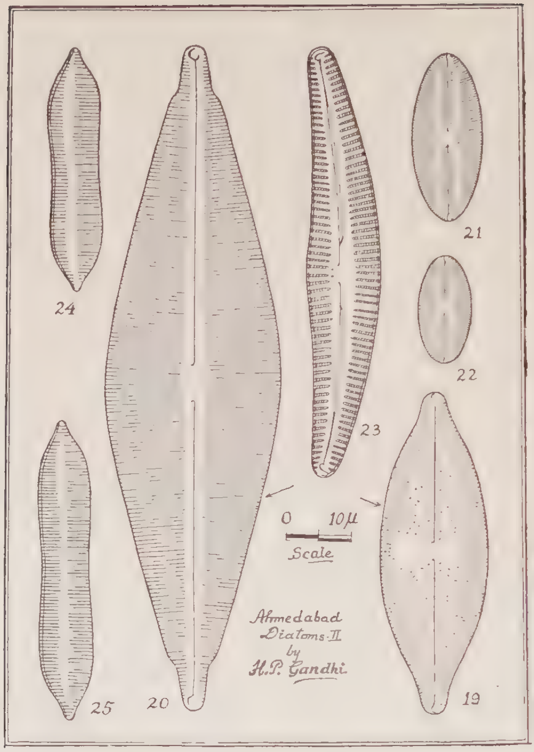

PLATE II

Fig. 19. *Anomoeoneis sculpta* (EHR.) CL. Arrow shows the faulty structure as recorded. - 20. *Navicula rhombiformis* sp. nov. - 21—22. *N. pygmaea* KÜTZ. - 23. *Cymbella cymbiformis* (KÜTZ.) V. H. v. *jimboii* (PANT.) A. CL. - 24—25. *Nitzschia apiculata* (GREG.) GRUN.

A quantitative study of the summer phytoplankton in four Central North Carolina ponds[1)]

by

RONALD C. PHILLIPS & L. A. WHITFORD

This study, in the lower Piedmont and Upper Coastal Plain of North Carolina, was undertaken during the summer of 1957 to determine whether there is any correlation between changes in bound phosphorus and phytoplankton numbers. Since no correlation was apparent (WHITFORD & PHILLIPS 1959) this paper is a report on the summer phytoplankton in four ponds in relation to other habitat factors. Its significance is that it presents a detailed, however short term, study of the phytoplankton in this area. WHITFORD (1958) listed only three papers dealing with the abundance and seasonal distribution of phytoplankton in the southeastern United States. Of these only two are of areas near where this study was made. SCHUMACHER (1956) studied a small area in southwestern Georgia, and EDDY (1930) reported on the plankton of Reel-foot Lake in Tennessee.

DESCRIPTION OF PONDS

Lake Johnson (Piedmont Pond No. 1) is a large pond on the border of the Piedmont about five miles southwest of the City of Raleigh. It is approximately 1 mile (2 km.) in length and 1/4 mile (0.6 km.) wide. The bed of the pond and its tributaries consists of silty sand to clay loam.

The water level remained relatively constant. During the period of study from June 1 to September 1, it varied only three inches (7.5 cm) and was quite clear for this area, except following heavy thunderstorms. One Secchi-disk reading in August was 14 dm. The pH

1) This work was aided by Contract No. AT-(40-1) 2100 with the Division of Biology and Medicine, U. S. Atomic Energy Commission.

varied from 7.0 to 7.6, during a dry period. The water temperature ranged from 24° C in early June to 28° C in late August.

Boone Pond (Piedmont Pond No. 2) is also in the lower Piedmont. It is a small pond approximately 200 yds. (190m.) wide and 150 yds. (145m.) long, in the northern part of the City of Raleigh. The pond lies on clay loam and the three tributary brooks flow over sandy or clay loam. The water is always muddy especially after heavy rainfall. At its muddiest a Secchi-disk reading of only 1.5 dm. was obtained. The pH varied from 6.4 to 7.0 during the period of study and the temperature from 30° C in early June to 24° C in late August.

Yong Pond (Coastal Plain Pond No. 1) is located 20 miles (30 km.) south of the City of Raleigh in the upper Coastal Plain. The pond is approximately 300 yds. (270 m.) long and 100yds. (90 m.) wide and lies on a fine sandy bottom. Its tributaries flow over and drain sands and sandy loams. The water is always quite clear and the level fell slowly about nine inches (22cm.) during the study. The pH remained close to 6.4 and the temperature varied from 30° C in early June to 24° C in late August.

Westbrook Pond (Coastal Plain Pond No. 2) is a small pond about 100 yds. (90 m.) by 100 yds. in size located 11 miles southeast of the City of Raleigh. It lies on sandy loam, and the watershed is cultivated fields of sandy loam. The water varied from clear to muddy after thunderstorms. At its muddiest a Secchi-disk reading of 6 cm. was obtained. The water level fell slowly almost 18 inches during the first two months and rose slightly above overflow level during the last few weeks of the study. The pH varied by about 0.5 from week to week. Readings from 6.4 to 7.4 were obtained. Water temperature rose from 27° C in early June to 32° C following heavy rains.

In late June sodium arsenite was used to eradicate pond weeds. This chemical killed hundreds of tadpoles in the pond. The effect of the chemical on the phytoplankton and later the effect of the decaying tadpoles is uncertain.

The depth of all four ponds averaged less than 7 ft. (2 m.) except for the lower end of Lake Johnson (Piedmont pond No. 1), which area is well below the collecting station.

Methods

Collections were made in all four ponds each week, and the same day of the week in any one pond. One collection made with a plankton net was studied to identify the principal species present. Four liters of water were collected from the first two feet for species counts. Water temperature, pH readings and other habitat notes such as water level, clearness of water, and visible blooms were made.

Within two hours the surface water sample was concentrated, by standard methods, in a Sedgwick-Rafter funnel and identifiable species of phytoplankton were immediately counted. A count of the organisms in ten random fields was made.

Another method of concentrating the organisms was tried. Fifteen liters of water were poured through a wet No. 20 silk plankton net, concentrated to 15 ml. and counts of the organisms were made in the counting cell. Results could not be correlated with sand filter counts, so this method was abandoned.

Analyses of the total phosphorus in each pond were made each week by a chemist in the N. C. State College Animal Nutrition Laboratory[1].) The water for analysis was filtered through Eaton-Dikeman No. 613 filter paper. This removed all debris and virtually all plankton organisms but allowed colloidal clay and other colloidal materials, containing adsorbed and bound phosphorus, to pass through. On several occasions water samples were filtered through a type ST-3 Sterilizing Filter made by Hercules Filter Corpn. This removed all colloidal particles down to 0.1 μ in size. Analysis of this filtered water water showed only traces of phosphorus. It had been planned to compare the levels of total and soluble phosphorus each week but ions from the sterilizing filter interfered, for a time, with the analyses.

Discussion

Except for several brief pulses, the plankton population was low in all four ponds. The flora of three ponds seems to be Caledonian, while that of Westbrook (Coastal Plain Pond No. 2) is more typical of a fertilized farm pond. The three other ponds were rich in species but low in individual organisms, and their floras differ in minor ways only from the typical Caledonian type.

There does not seem to be any correlation of type of phytoplankton population with any habitat factor except pH. It is not believed that the correlation is direct but that pH is merely an indication of certain water qualities.

Piedmont pond No. 1 (Lake Johnson) is believed to be most typical of the Piedmont ponds. It had a relatively stable pH (7.0—7.6). Extremely low numbers of Chlorococcales were present throughout the collecting period. The desmid population was also very low, but somewhat more abundant than the preceding group. Chlorophyceae were very low except for one small rise in late June. Euglenophyceae were almost non-existant. Dinophyceae and Chrysophyceae were also extremely low but

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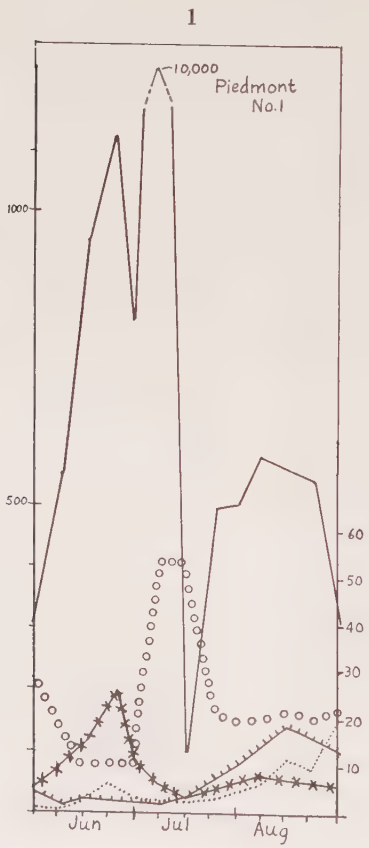
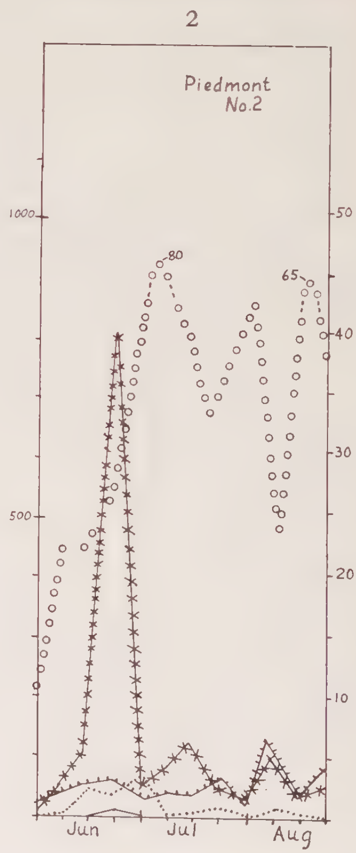
[1]) Thanks are due Dr. F. H. Smith who supervised the phosphorus analyses.

began a slight increase in late August. Cyanophyceae, represented by species of *Anabaena*, were abundant averaging over 500 colonies per cc during the whole three months. Two pulses occurred. One in late June reached 1,100 per cc. and one in July 10,000 per cc *Peridinium* appeared relatively more abundant in net collections than in S-R samples. *Synedra* rose slightly in numbers late in August. (Fig. 1).

Piedmont Pond No. 2 (Boone Pond) varied from week to week in pH between pH 6.4 and 7.0. Numbers of organisms were lowest in this pond. Chlorophyceae were most abundant and Chlorococcales were more abundant than in Piedmont pond No. 1, but the desmids lower. One small pulse in late June reached 800 per cc. Euglenophyceae, Bacillariophyceae and Dinophyceae were extremely low throughout the collecting period. *Dinobryon* was present during most of June and occasional *Synura* colonies were seen during the next two months. Cyanophyceae were recorded one week only in late June (Fig. 2).





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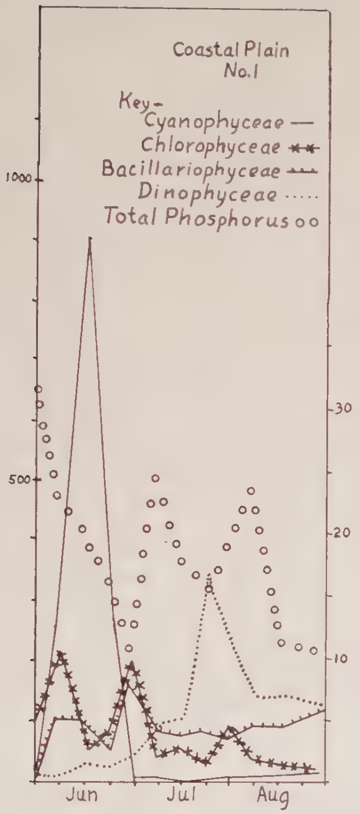

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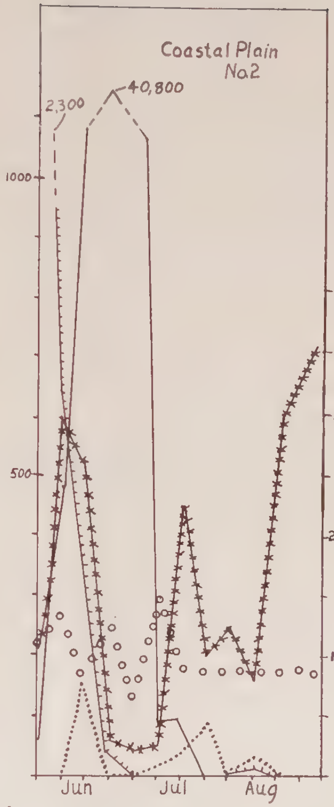


Figs. 1—4

Curves showing numbers of individuals per cc in four classes of algae. Scale on left. Total phosphorus in parts per million (circles) is also shown. Scale on right.

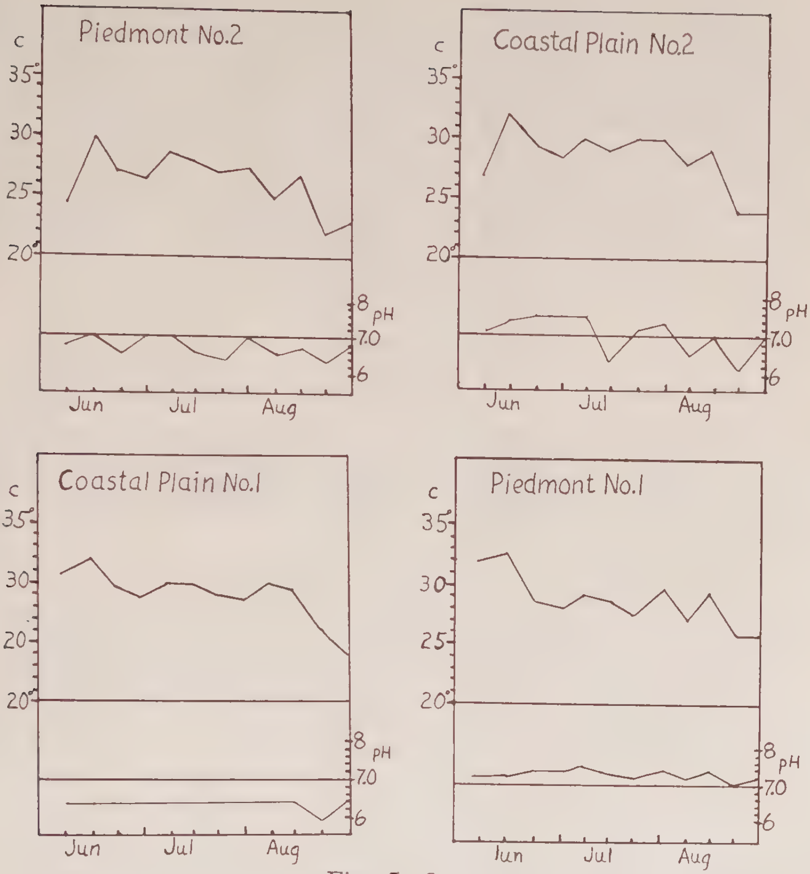
Coastal Plain pond No. 1 (Young pond) had a constant pH of 6.4 during the entire collecting period. It seems a quite typical Coastal Plain pond with clear water. Chlorophyceae were low except for two brief pulses of Chlorococcales in June which did not raise numbers of individuals above 90 per cc. *Eudorina* was the most abundant genus for the first five weeks. Desmids were extremely low and Euglenophyceae were never present in large numbers. Bacillariophyceae fluctuated around 80—100 per cc. most of the summer; *Synedra*, the principal genus, being most abundant in June and early July. Chrysophyceae were present, but in very low numbers, all summer. *Anabaena* was the most abundant genus during the second, third and fourth weeks but only occasional colonies were seen afterward. Dinophyceae, on the

other hand, were rare until the fifth week but increased after that time. During the seventh week species of *Peridinium* reached 340 per cc. but fell rapidly to about 160 per cc. in August. (Fig. 3.)

Coastal Plain pond No. 2 (Westbrook pond) seems typical of the fertilized pond described by WHITFORD (1958). The pH was extremely variable over a range of 1.0 unit. Chlorophyceae, especially the Chlorococcales were abundant and dominant during most of the summer. *Dictyosphaerium* was the principal genus and it had two major pulses one in early summer and one in late summer with two minor ones coming between. The desmids were very low in number, as were the Euglenophyceae, Dinophyceae, and Chrysophyceae. Bacillariophyceae were also almost non existent except for *Synedra*. This genus was very abundant (2,300 per cc.) during the first three weeks in June, but it also almost completely disappeared later. An enormous bloom of *Anabaena* appeared the second week and lasted three weeks, reaching over 40,000 colonies per cc. early in July. It was present in very small numbers the remainder of the summer, but *Anacystis cyanea* DR. & DAILY started to bloom at the very end of the collecting period. The large, short-period blooms of blue-greens and the large number of individuals of a few species of green algae make this pond typical of a fertilized pond anywhere in this state. (Fig. 4.)

The most abundant species in Piedmont pond No. 1 throughout the summer were *Anabaena levanderi* LEMM., *Peridinium wisconsinense* EDDY, and *Lepocinclis ovum* (EHR.) LEMM. in that order. In Piedmont pond No. 2 two species of *Dinobryon*, *D. sertularia* EHR. and *D. bavaricum* IMHOF were dominant for the first two weeks but *Synura uvella* EHR. replaced these during June and this species remained dominant for the rest of the summer.

In Coastal Plain pond No. 1 *Eudorina elegans* EHR. was dominant for the first six weeks except for a short-period bloom of *Anabaena circinalis* RABENH. *Peridinium wisconsinense* EDDY became the dominant during the last six weeks and associated with it were *Gymnodinium fuscum* (EHR.) STEIN, *Glenodinium aciculiferum* (LEMM.) LINDEMAN, and *G. penardiforme* (LINDE.) SCHILLER. In Coastal Plain pond No. 2 *Anabaena flos-aque* (LYNG.) BREB. formed an enormous bloom in late June and early July but previous to this bloom and following it *Dictyosphaerium pulchellum* WOOD was the dominant for the entire collecting period. Several species of Euglenophyceae were secondary in dominance all summer. Among them were *Euglena acus* EHR., *E. oxyuris* SCHMARDA, *E. gracilis* KLEBS, *Phacus longicauda* (EHR.) DUJARDIN, *Trachelomonas volvocina* EHR., and *T. gibberosa* PLAYFAIR. A large bloom of *Anacystis cyanea* DR. and DAILY began during the last week of collection.



Figs. 5—8.
Curves showing water temperature (scale on left), and pH (scale on right). (Reduce to one-half size)

SUMMARY

The phytoplankton of four ponds in the lower Piedmont and upper Coastal Plain of North Carolina was studied to find a possible correlation between bound phosphorus plankton numbers. No correlation was apparent therefore this paper reports a detailed study in relation to other habitat factors.

The ponds are all shallow (2 m.). The Piedmont ponds are high in colloidal clay while the Coastal Plain ponds are much lower. The pH ranged around 7.0 except for one Coastal Plain pond which remained close to pH 6.4. Water temperature ranged from 30° C in June to 23° C near the end of August.

Phytoplankton numbers were determined by the standard Sedgwick-Rafter method. Populations were low except for brief pulses. One Coastal Plain pond was typical of a fertilized pond and had several tremendous blooms of blue-green algae. The others supported a seemingly typical Caledonian flora, rich in species but low in number of individual organisms.

There was no clear correlation between phytoplankton populations and any habitat factor except pH. This correlation is probably not direct but only an indication of water quality.

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Contribution à la biologie de quelques Cichlides. III.

Phénomènes énergétiques en fonction de la température

par

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Introduction

La sensibilité des poikilothermes aux variations écologiques les plus nuancées est bien connue en hydrobiologie. Parmi les facteurs écologiques étudiés, la température a une influence particulièrement marquée sur leur comportement.

En pisciculture, la connaissance des relations entre la température de l'eau et la reproduction, la consommation de nourriture, la croissance et l'activité en général est d'une importance primordiale, non seulement pour interpréter les observations et les résultats mais surtout pour conduire rationnellement l'exploitation.

Le but de cette étude est de situer entre quelles limites de températures, une population donnée présente l'accroissement le plus élevé, tout en utilisant au mieux la nourriture consommée.

Les données obtenues n'ont de valeur que pour autant que la température optimale trouvée *in vitro* corresponde à la température optimale des étangs. Comme le montre cette étude, l'essai *in vitro* résoud le problème, plus rapidement et avec plus de précision que les études empiriques. Il est également vérifié que la technique utilisée fournit des informations compatibles avec les caractéristiques déjà connues de l'organisme étudié.

La connaissance des températures optimales permet au pisciculteur, non seulement de choisir l'espèce ou la variété adaptable à un milieu d'étang donné mais également de préconiser l'introduction de nouvelles espèces ou variétés dans les eaux libres, en vue de compléter la faune de certains lacs et rivières.

Organismes expérimentés

Le *Tilapia melanopleura* Dum herbivore et le *T. macrochir* Blgr planctonophage étudiés sont originaires du lac Moëro et ont été introduits en étangs depuis une quinzaine d'années.

Ces deux populations ont été dispersées depuis lors dans certains centres piscicoles du Congo méridional. Dans d'autres régions, des variétés locales des mêmes espèces ont été utilisées en pisciculture.

Cette étude est donc limitée aux populations originaires du lac Moëro ainsi qu'aux poissons de petite taille (± 25 g). Ayant atteint ce poids, la croissance des *Tilapia* envisagés commence à s'accélérer rapidement jusqu'au moment où leur organisme atteint la maturité sexuelle. Il semble donc indiqué, lorsque les poissons ont atteint ce stade si important pour leur croissance ultérieure, de choisir ce moment pour mener les expériences.

Méthode

Les observations sont basées sur des mesures, faites à différentes températures, de la consommation d'oxygène en repos et en activité et de la quantité de nourriture consommée.

1. La consommation d'oxygène en repos est établie suivant une technique décrite antérieurement (Spaas, 1958). Le poisson a d'abord été acclimaté à la température expérimentale et maintenu dans un état de repos complet. Il a été observé que le métabolisme en repos est le moindre le matin entre 6 heures 30 et 8 heures. Les données ainsi obtenues donnent une valeur représentative des besoins énergétiques nécessaires au métabolisme minimum d'entretien ou de base.

2. Pour mesurer la consommation d'oxygène en activité, la méthode est en principe la même que pour les mesures effectuées en état de repos.

Seules, les chambres de respiration et les conditions de lumière sont différentes.

Les chambres sont conçues pour permettre aux organismes étudiés de déployer une activité spontanée. Des bouteilles de dix litres, contenant au moins trois poissons de poids pratiquement égal, font fonction de chambres de respiration. Elles sont disposées de telle façon que les poissons ne voient pas l'expérimentateur, qui cependant observe les mouvements des poissons par une fente aménagée dans ce but.

Entre dix-huit et sept heures, les poissons restent dans l'obscurité; le reste du temps, ils sont exposés à une lumière constante, diffuse de

chambre. Il a été constaté que les poissons manifestent une activité spontanée et assez élevée, qui ressemble à celle observée lors de la distribution d'aliments dans les aquaria, entre 8 et 9 heures. La consommation d'oxygène, mesurée pendant cette période, rapporte les besoins énergétiques nécessaires au métabolisme des poissons en activité normale et pour une température donnée.

Les valeurs obtenues sont exprimées en millilitres d'oxygène consommé par heure, pour un kilo de poisson, dans un litre d'eau et ce, pour une pression de 660 mm de mercure. La régression des consommations d'oxygène par unité de poids, — individuel (en repos) ou des moyennes des groupes (en activité), — par rapport aux poids individuels (repos) ou moyennes des groupes, (activité) permet de calculer la consommation d'oxygène par unité de poids (en poissons de 25 g) et de comparer les données ainsi obtenues entre les différentes espèces et les diverses conditions (témperature, état de repos et d'activité).

3. Une nourriture aussi complète que possible est distribuée en suivant une technique qui permet de mesurer exactement la quantité consommée à la température expérimentale.

Soixante poissons de 10 à 40 g sont nourris dans des aquaria de 250 l. L'eau, qui provient d'un lac de barrage, passe par une installation d'épuration qui la traite au sulfate d'aluminium, de façon à précipiter l'humus en suspension et à obtenir un pH de 7.2 dans des bacs à température constante. De là, l'eau est répartie dans des aquaria contenant les différentes espèces.

L'eau est continuellement renouvelée et aérée. La concentration d'oxygène ne descend jamais en dessous de 4 ml/l à 660 mm/mercure. La nourriture se compose de 50 % de farine de maïs et de 50 % de farine de manioc; elle est distubuée par quantités mesurées dans des petits récipients.

Chaque quantité ne dépasse pas la ration journalière de la population. Au fur et à mesure que les récipients se vident, les rations sont renouvelées. De cette manière, il a été possible de contrôler la quantité consommée. Afin d'éviter toute fermentation, les déchets sont siphonés journellement au fond de l'aquarium.

Chaque semaine la quantité de nourriture consommée est totalisée et exprimée en moyenne par jour et en pourcent du poids vif des poissons.

Les poissons, dont la consommation de nourriture est mesurée, ne sont pas les mêmes pour toutes les températures. On a pris autant de lots, de 60 poissons qu'il y a de températures différentes éprouvées. Ces divers lots proviennent cependant d'une même population de géniteurs et ont été élevés dans des conditions identiques.

La nourriture, la qualité de l'eau, la source d'aération des aquaria

et la saison d'expérimentation sont identiques pour toutes les températures. Seule, la luminosité varie. Les températures de 19, 20 et 22°C sont réalisées dans des chambres froides où les aquaria sont éclairés au cours de la journée, par une lumière indirecte mais très intense. Les aquaria de la série soumise aux températures de 23,0 à 29,5°C sont éclairés par une lumière diffuse naturelle, plus ou moins constante et ce, en laboratoire. Il existe donc deux sources d'erreur qui n'ont pu être éliminées:

1. une différence possible entre les lots de poissons;
2. un effet éventuel des conditions d'éclairage.

Il en est tenu compte lors de l'exposé des résultats.

4. En soustrayant, pour une température donnée, la quantité d'oxygène consommée en repos, de celle consommée en activité, on obtient la quantité nécessaire pour l'activité seule, et ce, pour cette seule température. Cette soustraction, exécutée pour les différentes températures (entre 19 et 30°C,) permet d'établir la courbe de la consommation d'oxygène pour l'activité seule. Par ailleurs, permet la consommation de nourriture déterminée en fonction de la température et exprimée en pour cent du poids des poissons, de dresser une courbe qui exprime, par degré, la différence des pourcentages de nourriture consommée en fonction du poids vif.

En comparant les deux courbes, on constate qu'il existe des zones de températures, pour lesquelles l'augmention de consommation de nourriture est, proportionnellement, plus importante que la consommation d'oxygène nécessitée pour l'activité seule et/ou pour le métabolisme total en activité. Ces zones correspondent à des conditions pour lesquelles la quantité de nourriture consommée est, proportionnelement, la moins utilisée pour l'activité et donc disponible pour l'accroissement. Elles définissent ainsi, pour ce qui concerne la température, les conditions optimales au point de vue zootechnique.

Résultats

1. *Tilapia melanopleura*.

La régression des consommations d'oxygène en état de repos par rapport aux poids individuels donne le métabolisme d'oxygène par unité de poids (kg) en individus de 25 g (tableau I). Les valeurs ainsi obtenues, qui constituent le graphique 1, forment une courbe qui est, chez *T. melanopleura* en repos, caractérisée par une partie droite pour les températures de 15 à 27°C et ce, suivant une équation linéaire ($Y = 7{,}346\ X - 66{,}95$, pour $P = 0{,}01$). A 30°C la consommation d'oxygène a cependant tellement augmenté que,

Tableau I

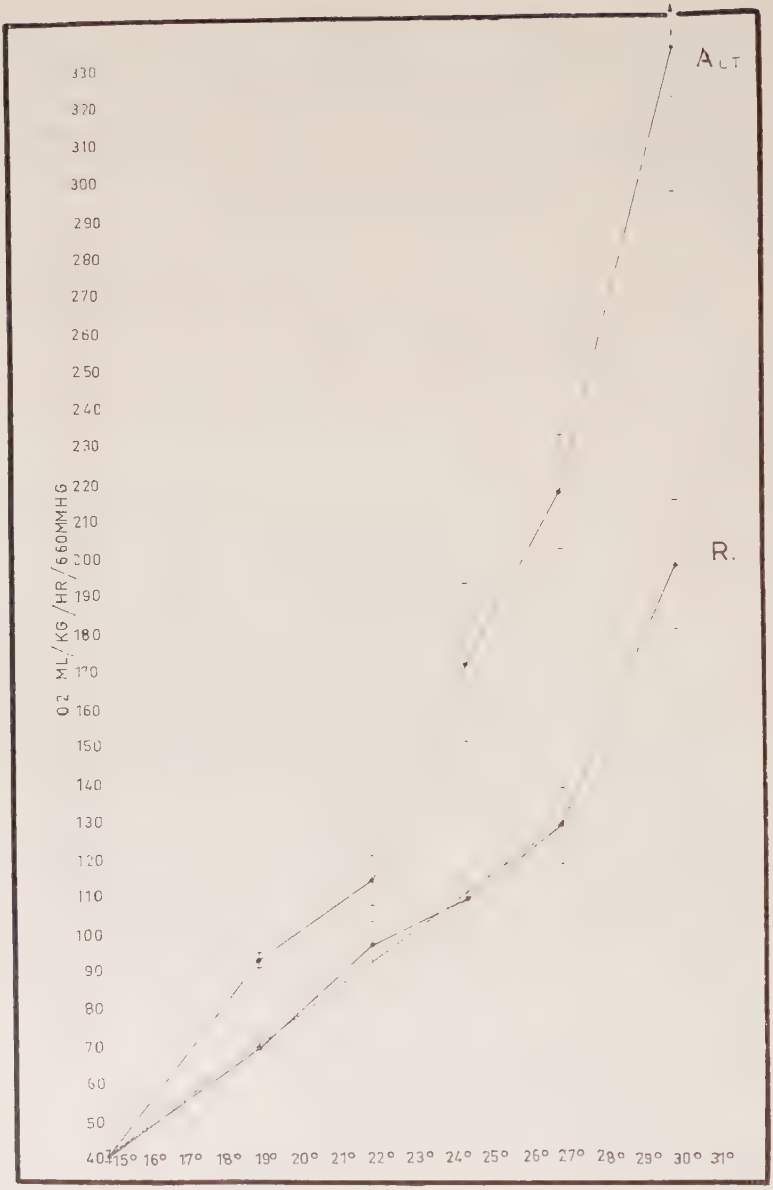
La consommation d'oxygène en ml/l/h/ en repos et en activité.
(660 mm de mercure).

	Température (°C)	Poids (X)	O_2 con/kg/h (Y)	Régression	Pour X = 25 g	N
nelano- leura epos	15,0	20,41 ± 1,014	43,57 ± 0,656	Y = 47,57—0,196 X	Y = 42,67	7
	19,0	25,63 ± 1,475	70,60 ± 1,587	Y = 95,87—0,986 X	Y = 71,22	17
	22,0	24,97 ± 1,676	99,21 ± 2,862	Y = 137,36—1,528 X	Y = 99,16	13
	24,5	25,23 ± 0,943	110,4 ± 3,300	Y = 196,05—3,395 X	Y = 111,17	12
	27,0	25,2 ± 0,790	129,7 ± 4,196	Y = 256,4 —5,028 X	Y = 130,70	8
	30,0	25,45 ± 1,516	196,6 ± 7,619	Y = 321,2 —4,896 X	Y = 198,80	10
macro- chir epos	16,0	18,27 ± 2,842	67,43 ± 3,545	Y = 74,08—0,364 X	Y = 64,98	7
	19,0	23,90 ± 3,057	76,80 ± 2,854	Y = 98,31—0,901 X	Y = 75,81	10
	22,0	23,12 ± 2,147	96,44 ± 4,368	Y = 139,93—1,881 X	Y = 92,90	10
	24,5	26,01 ± 1,445	107,6 ± 3,274	Y = 156,78—1,891 X	Y = 109,51	12
	27,0	23,84 ± 1,679	135,75 ± 2,147	Y = 162,07—1,104 X	Y = 134,47	8
	30,0	25,66 ± 2,302	163,44 ± 4,400	Y = 176,37—0,504 X	Y = 163,77	9
mela- pleura ctivité	19,0	26,4 ± 1,212	94,4 ± 0,900	Y = 104,64—0,380 X	Y = 94,94	7
	22,0	22,33 ± 1,200	119,0 ± 2,685	Y = 144,34—1,135 X	Y = 115,97	7
	24,5	23,25 ± 2,105	180,37 ± 8,986	Y = 271,37—3,914 X	Y = 173,52	8
	27,0	26,7 ± 1,868	216,2 ± 6,585	Y = 255,07—1,456 X	Y = 218,67	9
	30,0	29,55 ± 6,791	313,28 ± 15,490	Y = 458,22—4,905 X	Y = 335,59	7
macro- chir	18,0	23,54 ± 1,992	84,28 ± 5,217	Y = 145,08—2,583 X	Y = 80,51	7
	22,0	18,6 ± 2,034	157,5 ± 7,043	Y = 199,74—2,271 X	Y = 142.97	8
	24,5	25,47 ± 2,059	175,43 ± 7,000	Y = 285,66—4,328 X	T = 77,46	7
	27,0	22,7 ± 1,830	226,16 ± 2,503	Y = 273,03—2,043 X	Y = 221,95	9
	30,0	27,13 ± 5,317	257,4 ± 10,330	Y = 311,14—1,981 X	Y = 261,62	7

même en considérant les limites fiduciaires, ce point tombe complètement de la droite donnée par l'équation citée plus haut.

A la suite de quelques mesures de consommation d'oxygène en c o n d i t i o n s d'a c t i v i t é, il apparut qu'à la température de 15°C, le poisson ne bouge pas et qu'il ne consomme pas plus d'oxygène qu'à l'état de répos. La courbe établissant les valeurs obtenues en état d'activité aux autres températures (graphique 1) montre que la consommation d'oxygène augmente rapidement entre 15 et 19°C, et encore plus à partir de 22°C.

Entre 19,0 et 24,5°C, la courbe est caractérisée par une inflexion à 22°C. La moyenne avec les limites fiduciaires à 22°C se situe nette-



GRAPHIQUE 1.

La consommation d'oxygène chez *T. melanopleura* en état de repos (R) et d'activité (Act), exprimée en ml l h kg/660 mm de mercure et calculée en poissons de 25 g. Les points représentent les moyennes et les traits horizontaux, reliés par des lignes pointillées aux moyennes, caractérisent les limites fiduciaires (P 0,05). La ligne interrompue représente la régression très significative (P = 0,01) des mesures obtenues en repos, entre 15 et 27°C

(Y = 7,346 X — 66,95).

ment plus bas qu'une droite qui relie les limites fiduciaires inférieures à 19,0 et 24,5°C.

Cette inflexion à 22°C apparaît encore plus marquée dans la courbe représentant la consommation d'oxygène destinée uniquement aux besoins énergétiques nécessaires à l'activité seule (graphique 2 et tableau II).

TABLEAU II

La consommation d'oxygène en activité moins la consommation en repos chez *T. melanopleura*.

Température (°C)	Act. - R.	d. F.	Limites fiduciaires (P = 0,05)
19,0	23,72 ± 2,572	22	± 5,332
22,0	16,71 ± 4,589	18	± 9,641
24,5	62,35 ± 5,862	18	± 12,316
27,0	87,97 ± 6,853	15	± 14,604
30,0	136,79 ± 15,748	15	± 33,558

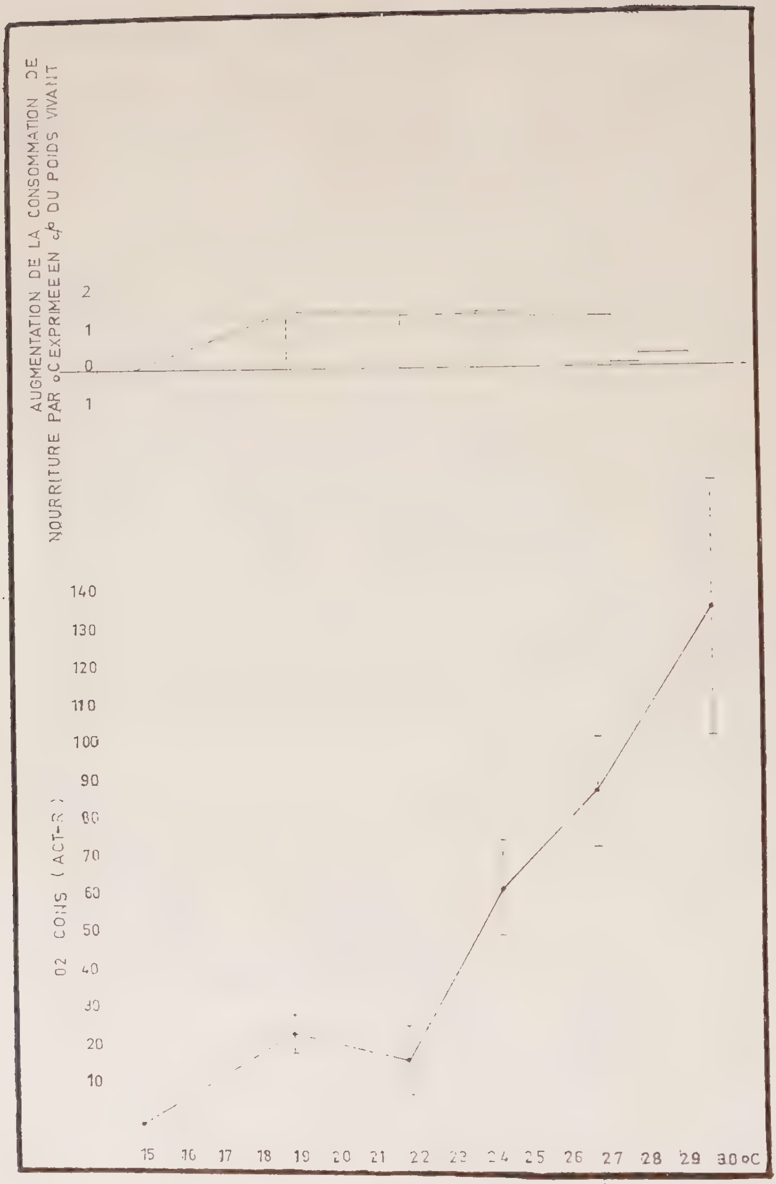
Malgré les déviations des moyennes, représentées par les limites fiduciaires aux graphiques 1 et 2, il est donc statistiquement probable (P = 0,05) qu'une inflexion des besoins énergétiques totaux (graphique 1) et partiels, destinés à l'activité seule, (graphique 2) se situe à 22°C.

La consommation de nourriture, exprimée en pour cent du poids vif et par jour, est relativement stable pour une même température (tableau III).

TABLEAU III

La nourriture consommée par jour, exprimée en % du kg de poisson (pesé vivant).

Température (°C)	*T. melanopleura*	N.	*T. macrochir*	N.
19,0	1,9 ± 0,131	5	1,98 ± 0,147	5
20,0			2,57 ± 0,142	6
22,0	6,4 ± 0,135	4		
23,0			4,36 ± 0,127	6
24,0	9,2 ± 0,121	6	5,9 ± 0,143	6
24 8	10,4 ± 0,142	6		
25,0			6,71 ± 0,189	
27,0			9,4 ± 0,201	5
27,5	14,1 ± 0,172	6		
28,2	14,2 ± 0,297	4		
29,5	14,7 ± 0,352	4	11,1 ± 0,378	4



GRAPHIQUE 2.

Partie inférieure: la consommation d'oxygène utilisée pour les besoins énergétiques d'activité et ses limites fiduciaires (P = 0,05) chez *T. melanopleura*.

Partie supérieure: l'augmentation de la consommation de nourriture par degré, mesurée par intervalle, est indiquée par les lignes pointillées.

Cette constance dans les mesures est remarquable. Un même lot a servi pour mesurer pendant quatre à six semaines consécutives, la consommation à une même température.

Ce phénomène s'explique étant données les conditions (1) de nourriture déficiente et (2) de surpopulation, inévitables dans cette étude:

1) Compléter l'alimentation artificielle par une nourriture naturelle aurait faussé les résultats. Par la prolifération du plancton et des plantes, il serait devenu impossible de mesurer les quantités réellement consommées.

2) Diminuer le taux de population a pour résultat que la consommation devient irrégulière. Un phénomène analogue a été observé par Brown (1946 a) chez les truites.

Il est normal qu'une population très dense, placée dans des conditions de nourriture déficiente, se nourrisse aussi intensivement que l'organisme le permet. De cela, on a supposé la constance dans les mesures obtenues.

Ces données n'ont donc pas de valeur absolue mais une valeur comparative.

L'augmentation de cette consommation par degré C (tableau IV et graphique 2), est pratiquement linéaire entre 19,0 et 27,5°C ($Y = 1{,}435\ X - 25{,}265$, pour $P = 0{,}01$) et diminue pour des températures supérieures et inférieures.

Tableau IV

Augmentation de la consommation journalière de nourriture par degré (°C) et exprimée en % du kg de poisson.

Températures expérimentales (°C)	*T. macrochir*	*T. melanopleura*
19,0—22,0		1,50
19,0—20,0	0,59	
20,0—23,0	0,59	
22,0—24,0		1,40
23,0—24,0	1,54	
24,0—24,8		1,50
24,0—25,0	0,81	
24,8—27,5		1,37
25,0—27,0	1,34	
27,0—29,5	0,68	
27,5—28,2		0,14
28,2—29,5		0,38

On peut se demander maintenant si la différence entre les conditions de lumière et/ou entre lots prélevés au hasard dans une même population aurait eu un effect tel, que l'augmentation constante de la consommation de nourriture en eut été le résultat. Cela semble cependant si peu probable puisqu'il faudrait alors admettre qu'une double erreur resulte en une simple fonction linéaire, entre certaines limites, de la température.

Si on accepte donc cette augmentation constante et si on la compare avec l'inflexion à 22°C dans les courbes représentant les besoins énergétiques totaux et partiels (activité), il reste finalement à déduire (graphiques 1 et 2) que la nourriture consommée n'est pas dépensée à 22°C dans la même mesure, pour les besoins énergétiques, qu'aux autres températures.

Il est encore possible que ce surplus de nourriture disponible pour l'organisme soit moins bien assimilé à 22°C qu'aux autres températures.

Supposer cela est cependant contraire à toutes les données, dont on dispose, concernant le comportement de *T. melanopleura* en fonction de la température.

Vingt-deux degrés se situent presque à mi-chemin entre les températures léthales minima (7,8°C) et maxima (38,7°C), trouvées chez ces mêmes poissons (cfr SPAAS, 1959 a).

D'autre part, il est apparu de l'analyse des causes de mortalité lors des vidanges en pisciculture (SPAAS, 1959 b) que le pourcentage de survie est en général le plus élevé aux températures situées entre 19 et 22°C, par rapport aux autres températures expérimentales, 25° et 28°C.

Puisque 22°C se situe dans une zone de température optimale, il semble logique d'accepter que la nourriture consommée à cette température soit au moins aussi bien, si pas mieux assimilée qu'aux autres températures. Le surplus consommé à 22°C est donc probablement destiné à l'accroissement de l'organisme.

Cette conclusion confirme certains résultats obtenus par A. COCHE, Assistant à la Station. Ce dernier a prouvé que la croissance optima en vivier a été obtenue, chez les alevins de *T. menalopleura*, à une température moyenne située aux environs de 22°C.

2. *Tilapia macrochir.*

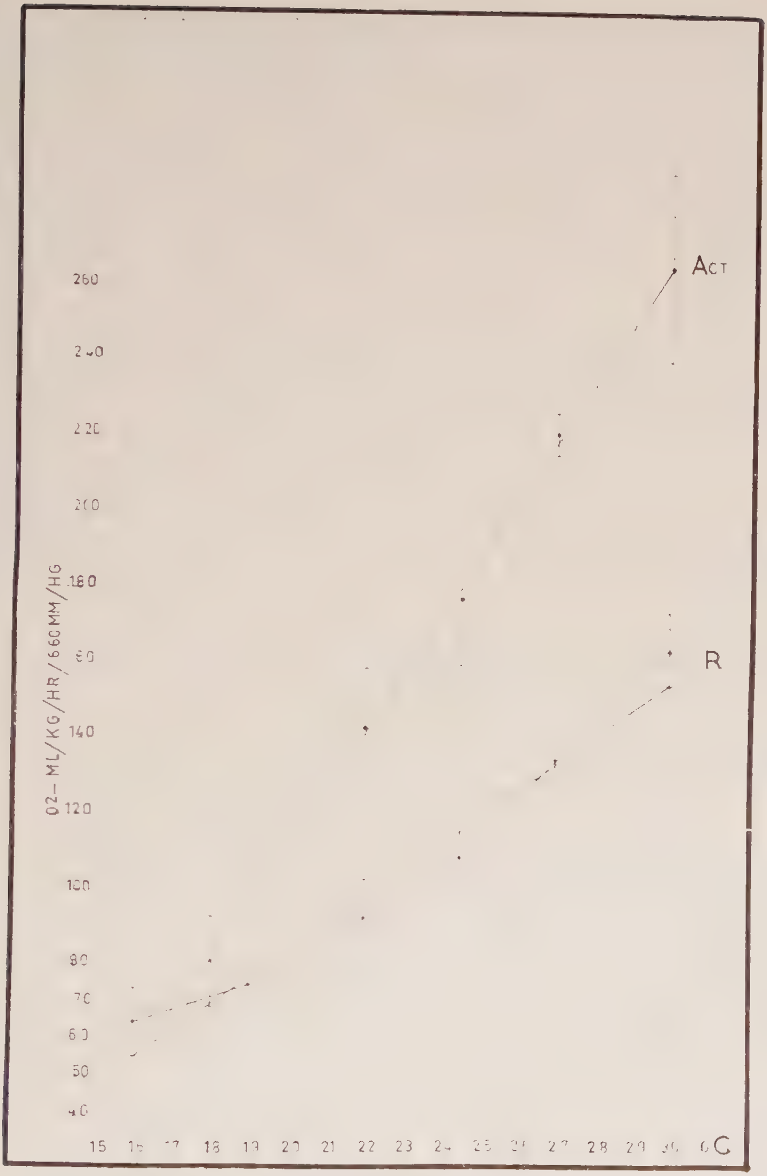
La consommation d'oxygène en état de repos, par unité de poids pour des individus de 25 g (tableau I), s'exprime en fonction de la température par une équation linéaire (YR = 7,09 X — 56,73, pour P = 0,01).

Au graphique 3, les valeurs obtenues aux températures extrêmes (16 et 30°C) et celles enregistrées à 22 et 24°C se situent respectivement au dessus et en dessous de cette droite. Une certaine inflexion semble donc exister aux environs de ces températures intermédiaires.

Au contraire, les valeurs obtenues en état d'activité suivent de beaucoup plus près l'équation linéaire (YA = 15,219 X — 192,94, pour P = 0,01) qui représente la variation de la consommation d'oxygène en fonction de la température (graphique 3).

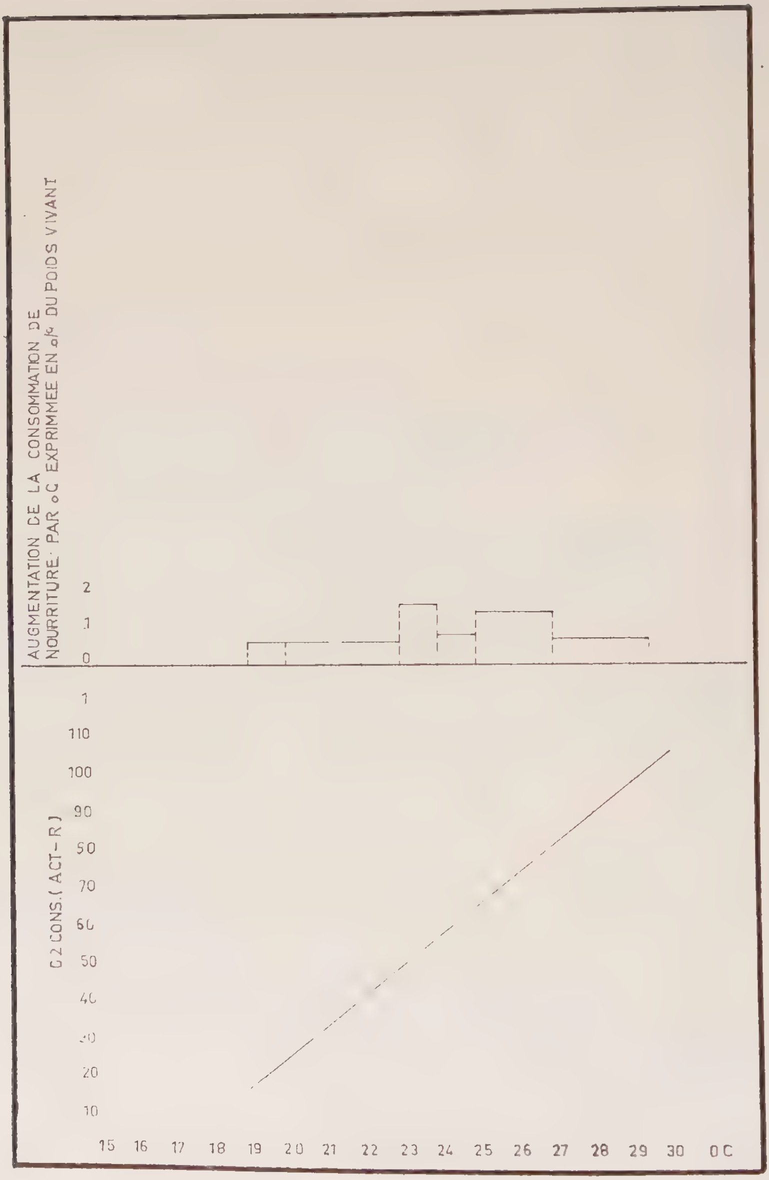
La différence entre les deux fonctions (YA — YR) (YD = 8,129 X — 136,21, pour P = 0,01) represente les besoins énergétiques nécessaires à l'activité seule, également sous forme d'une fonction linéaire de la température (graphique 4).

La quantité de nourriture consommée aux



GRAPHIQUE 3.

La consommation d'oxygène chez *T. macrochir* en état de repos (R) et d'activité (Act) est exprimée en ml/l/h/kg/660 mm de mercure et calculée en poissons de 25 g en fonction de la température. Les points représentent les moyennes et les traits horizontaux, reliés par des lignes pointillées, caractérisent les limites fiduciaires (P — 0,05). Les droites continues sont les lignes de la régression très significative (P = 0,01) en état de repos ($Y_R = 7{,}09\ X - 56{,}73$) et d'activité ($Y_A = 15{,}219\ X - 192{,}94$).



GRAPHIQUE 4.

Partie inférieure: la fonction linéaire ($Y_A - Y_R = Y_D = 8{,}129\ X - 136{,}21$) très significative ($P = 0{,}01$) représente la consommation d'oxygène utilisée pour les besoins énergétiques d'activité.

Partie supérieure: l'augmentation de la consommation de nourriture par degré, mesurée par intervalle, est indiquée par les lignes pointillées.

différentes températures, exprimé en pour cent du poids des poissons, augmente avec la même intensité entre 19 et 20°C (0,59 %) et entre 20 et 23°C (0.59 %). Entre 23 et 24°C, cette consommation augmente de 1,54 % du poids de l'organisme; elle diminue un peu entre 24 et 25°C (0,81 %) pour présenter un second maximum, quoique inférieur au précédent, entre 25 et 27°C (1,34 %). Aux températures plus élevées (27,0 et 29,5°C) l'augmentation par degré (0,68 %) retombe à peu frés au niveau de l'intervalle 19 et 23°C (tableaux III et IV; graphique 4).

Le premier maximum est très net puisque l'intervalle n'est que d'un degré. Le deuxième, parce que trouvé sur deux degrés, peut éventuellement se décomposer en deux niveaux: un inférieur et un supérieur. Ce dernier peut être égal ou même plus élevé que le premier maximum trouvé entre 23 et 24°C. L'augmentation de la consommation entre 23 et 24°C et entre 25 et 27°C est cependant remarquable, quand on considère la constance de la consommation hebdomadaire per degré. A première vue, il ne semble même pas exclu que (1) la différence en luminosité et/ou (2) le choix du lot aient provoqué la grande variation enregistrée.

La lumière est stable entre 19 et 20°C (chambre froide) et change, mais d'une façon constante, entre 23,0 et 29,5°C (salle d'aquaria).

Si cela a eu un effet, il se produit donc entre 20 et 23°C. Or, l'augmentation de la consommation reste constante entre ces limites.

Puisque les maxima constatés se manifestent dans des conditions de lumière identiques, il reste encore, comme source d'eurreur possible, l'échantillonnage.

Les maxima se situent seulement aux températures intermédiaires, tandis que les valeurs obtenues aux températures extrèmes sont constantes.

Pour que le choix des lots puisse être erroné, il faut que l'on prélève des lots non représentatifs, uniquement pour les températures intermédiaires.

La façon dont les 60 poissons par lot ont été prélevés, rejette la possibilité d'une telle erreur d'échantillonnage; les conclusions restent donc valables.

Les variations dans la consommation de nourriture, comparées avec la régression linéaire des besoins énergétiques, montrent donc qu'un excès de nourriture est consommée entre 23 et 24°C et entre 25 et 27°C.

Ce surplus de nourriture devient logiquement disponible pour l'accroisement de l'organisme.

Supposer que cette nourriture soit moins bien assimilée à ces températures est contraire à toutes les informations recueillies concernant les relations entre les températures extérieures et le comportement de *T. macrochir*.

Lors de l'étude des limites de température de *T. macrochir*, on a remarqué (Spaas, 1959 a) qu'à mi-chemin les températures léthales les plus extrêmes, se situe la température de 23 à 31°C.

Analysant les causes de mortalité lors des vidanges d'étangs (Spaas, 1959 b),

on trouve, en effectuant des observations à des intervalles de 3°C (les température expérimentales étant 19, 22, 25 et 28°C), que dans les deux conditions de boue en suspens, sous insolation et sous ombrage, le pourcentage de survie est plus élevé à 22 qu'à 19 et 25 et, surtout, qu'à 28°C.

Puisque les températures de 23 et de 24°C sont situées dans une zone de températures optima, il est donc probable que le surplus de nourriture consommée est assimilé et utilisé pour l'accroissement de l'organisme.

Il n'est pas exclu qu'un deuxième optimum se situe entre 25 et 27°C. Il est cependant peu probable qu'il ait la même signification que le premier puisque on ne se trouve plus dans une zone aussi optima que la première. Pour la truite *S. trutta* L., BROWN (1946 b) signale l'existence de deux températures optima pour la croissance. La premiere, la plus importante, est située à 8°C et la seconde, aux environs de 18°C.

DISCUSSION

Le métabolisme et la consommation de nourriture, mesurés chez *T. menalopleura* et *T. macrochir* à différentes températures et suivant des méthodes identiques, ont permis de déterminer la température optima pour l'accroissement, mais par des interprétations opposées, de ces deux espèces.

Chez *T. melanopleura*, les courbes du métabolisme total (activité et entretien) et du métabolisme d'activité caractérisent, par une inflexion nette, la zone de température optima, puisque l'accélération de la consommation de nourriture reste constante. La température optima pour l'accroissement de *T. macrochir* a été, au contraire, trouvée grâce à un sommet dans la courbe représentant l'accélération de la consommation de nourriture, cependant que l'accélération des phénomènes métaboliques est restée constante.

L'intérêt pratique et scientifique des résultats obtenus, en même temps que la valeur de la méthode appliquée, sont discutés;

1. Connaissant les fluctuations de la température au cours de l'année, on peut, compte tenu des pourcentages de nourriture consommée (tableau III), intensifier ou diminer l'alimentation en fonction de la température de l'eau. Les données du tableau III n'ont pas de valeur absolue puisqu'il faut également tenir compte de la qualité de la nourriture.

2. La faible croissance en saison froide, bien connue en pisciculture, s'explique par le peu de nourriture consommée aux températures inférieures à 19°C.

3. L'absence de croissance pendant les périodes les plus chaudes

de l'année se justifie par l'accélération considérable des besoins énergétiques par rapport à la faible augmentation de la quantité de nourriture consommée.

4. L'existence d'une dualité entre ces deux phénomènes (métabolisme et consommation de nourriture) incite à reconsidérer la valeur de la température léthale la plus élevée (38,7°C), établie antérieurement (SPAAS, 1959 a) pour ces espèces.

La consommation de nourriture n'augmente plus proportionnellement aux besoins énergétiques, à partir de 27,5°C chez *T. melanopleura* et de 28°C environ chez *T. macrochir*. Ce dernier chiffre a été déduit de quelques mesures complémentaires faites à la fin de la période d'observation.

Dans la zone comprise entre 38,7°C (témpérature léthale) et la température à partir de laquelle l'accélération de la consommation de nourriture diminue, la croissance doit normalement d'abord s'arrêter et ensuite, au fur et à mesure que la température s'approche de la limite léthale, l'organisme doit s'affaiblir progressivement.

Les populations de *T. melanopleura* et de *T. macrochir* ne peuvent donc pas survivre en subissant des températures constamment plus élevées que 27 et 28°C.

BRETT (1956) discutant la signification écologique de la température léthale la plus élevée (ultimate upper lethal temperature) correspondant à 38,7°C chez les deux espèces de *Tilapia,* prouve, en se basant sur les études d'un nombre considérable de races et d'espèces, que cette limite supérieure dépasse de loin les températures rencontrées dans le biotope de la population. Malgré cette différence entre les températures léthales les plus extrèmes et les températures extérieures les plus élevées, il existe, comme le signale HART (1952) et BRETT (1956), une relation spécifique entre le niveau de ces limites et l'habitat des populations; celles habitant les régions les plus chaudes sont caractérisées par les températures léthales les plus élevées.

L'existence d'une telle relation n'explique cependant pas le phénomène tel qu'il a été constaté. Il doit exister, comme BRETT (1956) l'a déjà supposé, un mécanisme physiologique qui limite la distribution de la population et qui se distingue nettement de la température léthale la plus élevée.

Ce mécanisme semble répondre au ralentissement dans l'augmentation de la consommation de nourriture, par rapport à l'accélération du métabolisme d'activité.

Cette conclusion a d'autant plus de valeur que l'accélération de l'activité, telle qu'elle a été mesurée, n'est pas une activité forcée mais s p o n t a n é e.

L'activité forcée et maximale, mesurée dans une chambre de rotation qui tourne à une vitesse telle que le poisson qui nage contre

le courant reste sur place (Fry & Hart, 1948), suit, en fonction de la température, des courbes très typiques et d'une signification écologique importante. Brett (1956) a prouvé cette importance en discutant les résultats obtenus par Fry (1947 et 1948), Fry & Hart (1948) et Graham (1949).

Le point écologiquement important de ces courbes est la température à laquelle l'activité atteint son maximum en fonction de la température.

Brett (1956) établit le parallélisme qui existe entre la situation de ce maximum par rapport à la température léthale la plus élevée et la distribution de la population. Les populations caractérisées par une même zone de température léthale élevée sont d'autant plus thermophiles que le maximum de la courbe se rapproche davantage de la limite léthale.

Le même auteur souligne ainsi un deuxième phénomène (en dehors de la température léthale la plus élevée) qui est également en relation avec le mécanisme physiologique qui limite la distribution de l'espèce à des zones inférieures à la température léthale la plus élevée.

Il est possible que ce maximum d'activité forcée se manifeste à la température déterminée comme réellement limitante.

Si notre étude s'était basée sur la méthode utilisée par Fry & Hart (1948) (chambre de rotation) pour la mesure du métabolisme d'activité, il se pourrait donc qu'on aurait constaté un fléchissement parallèle entre les courbes de consommation de nourriture et d'activité. Toute conclusion concernant la température et le mécanisme qui limite la distribution de la population aurait été impossible dans ce cas.

L'étude des besoins énergétiques des deux populations de *Tilapia* considérées a fourni quelques enseignements:

1. Leur température optima pour la croissance.
2. Leur consommation de nourriture (ayant une valeur comparative pour un plan d'alimentation en fonction de la température).
3. Le ralentissement de la croissance aux températures inférieures et supérieures, éloignées de quelques degrés seulement de l'optimum, a pu être expliqué.
4. Le mécanisme qui limite la distribution de la population au delà d'une température, qui peut éventuellement être fortement inférieure à la température léthale supérieure, a été déterminé.

Les trois premiers points ne concernent directement que les races locales de *Tilapia* étudiées.

Le quatrième point est relatif aux populations en observation mais constitue en outre un nouveau principe d'application générale.

En conclusion, l'ensemble de ces observations fixe, pour chacune

des populations, des zones de température, caractéristiques des zone optimales subléthales et léthales.

Toutes ces informations étant basées sur les mesures de la consommation de nourriture et du métabolisme en fonction de la température, on peut considérer ces deux phénomènes comme induisant l'adaptation d'une forme à un milieu donné.

De nombreuses études ont d'ailleurs prouvé que l'adaptation d'une forme à des températures déterminées est liée à la régulation de l'intensité métabolique. SPÄRCK (1936) FOX & WINGFIELD (1937), PEISS & FIELD (1950), MINAMORI (1952), HALSBAND (1953) SCHMEING-ENGBERDING (1953), SCHOLANDER et alii (1953), FLÔRKE et alii (1954) et PROSSER (1955) ont constaté entre des populations et des espèces de poikilothermes, comparées à une température moyenne identique, un niveau métabolique moins élevée chez les plus thermophyles.

En 1916, KROGH avait déjà avancé l'hypothése qu'un tel mécanisme de compensation (cfr BULLOCK, 1955) permettrait aux formes apparentées de s'adapter à différentes températures. L'hypothèse de KROGH a été contredite, dans une certaine mesure, par FOX (1936) avec *Antedon* spp. et BERG (1953) avec *Ancylus fluviatilis*. FOX a basé ses conclusions sur les consommations d'oxygène à deux températures pour l'espèce nordique et a deux autres pour l'espèce tempérée.

BERG (1953) a expérimenté deux formes *d'Ancylus fluviatilis*, dont l'une vit à 11°C (Funder Aa) et l'autre à 18°C (Rørbaek Sø).

A 11°C, la consommation d'oxygène de Rørbaek était plus élevée que celle de Funder mais la population Rørbaek n'a été acclimatée que pendant 20 h., à 11°C et, il n'est pas prouvé que cette durée suffit pour une acclimatation complète. Il est donc possible que la population Rørbaek, qui n'était pas encore acclimatée à 11°C, ait manifesté un métabolisme plus élevée que celui qui correspond réellement à cette température.

A 18°C, la population Funder n'a probablement pas eu le temps non plus (20 h.) de s'acclimater et d'accélérer son métabolisme jusqu' au niveau normal correspondant à cette température.

Il est donc possible de retenir l'hypothèse de KROGH (1916) et de la généraliser, du moins pour les *Teleostei*, puisque aucune contradiction n'est connue dans cet ordre.

Si la relation entre l'intensité métabolique d'un organisme et son habitat n'intervient pas directement dans cette étude, elle est d'une grande importance pour résoudre le problème de la taille réduite des *Tilapia* spp. en région équatoriale.

Les principes qui expliquent la faible croissance des écotypes de

T. melanopleura et de *T. macrochir* habitant les régions équatoriales ont retenu l'attention.

On appelle ici région équatoriale, les eaux du fleuve Congo qui sont caractérisées par une température plus élevée et par le fait qu'elles sont plus pauvres en éléments nutritifs que les eaux habituées par les écotypes originaires du lac Moëro.

L'influence de la température a été observée plus spécialement:

1. Le métabolisme pour une température donnée est diminué chez les populations et chez les espèces adaptées aux régions plus chaudes.

2. Une corrélation négative existe entre la taille et la dispersion et ce, en fonction de la température, chez certains poissons, dont les espèces sont apparentées d'après HENKING (1929) avec *Salmo* spp., HART (1948) avec *Merlucius* spp., et GUNTER (1950) avec différentes espèces de poissons de mer. Cette corrélation est d'ailleurs généralement connue dans certains groupes de salmonides et de cyprinides.

HEUTS (1947 a) distingue dans une même espèce, *Gasterosteus aculeatus* L., deux populations dont la plus thermophyle présente la plus faible taille.

Cette relation entre la taille et la température de l'habitat s'applique directement aux écotypes de *T. melanopleura* et de *T. macrochir*. Les populations adaptées aux régions plus chaudes ont une taille plus réduite que les populations adaptées aux régions où règnent des températures moins élevées.

Un deuxième élément caractérise le biotope des régions équatoriales envisagées: le manque d'éléments nutritifs. Compte tenu de la faible valeur alimentaire de ces milieux, l'adaptation physiologique des écotypes de *Tilapia*, qui habitent ces biotopes, ne peut être réalisée que par une diminution des besoins énergétiques.

Ce phénoméne implique une diminution du métabolisme et explique en même temps le ralentissement des phénomènes de croissance. En suivant ces déductions, on a appliqué le même raisonnement que HEUTS (1953). Cet auteur justifie la croissance ralentie de *Caecobarbus geertsii* BLGR., habitant des grottes (milieu très pauvre en éléments nutritifs), et la compare à celle de *Barbus holotaenia* BLGR. trouvé dans un biotope voisin (plus riche en nourriture), en dehors des grottes.

L'intensité métabolique ainsi que la résistance restent finalement encore conditionnées par d'autres facteurs écologiques, tels certains ions qui ont une influence directe sur l'osmorégulation et ses phénoménes énergétiques propres.

Les besoins énergétiques liés à l'osmorégulation sont très importants par rapport aux besoins énergétiques totaux de l'organisme. (WIKGREN, 1953).

L'effet de certains ions sur l'osmorégulation, l'intensité métabolique et la résistance aux températures a été décrit par SCHLIEPER et ALII (1952) chez *Squalius cephalus* HECK, *Planaria gonocephala* DUG et *Planaria alpina* DANA; par HALSBAND (1953) chez *Squalius cephalus* HECK et *Trutta iridea* W. GIBB. et par FLÖRKE et ALII (1954) chez *Squalius cephalus* HECK et *Trutta iridea* (W. GIBB.).

Cette question ne peut être discutée ici puisqu'on ignore à quel degré un milieu est plus ou moins hypotonique par rapport à l'autre.

Toutes les données recueillies confirment cependant l'hypothèse suivant laquelle les écotypes de *T. melanopleura* et de *T. macrochir*, représentés dans les eaux équatoriales du Congo, ont un métabolisme plus faible que les écotypes qui habitent des régions plus froides, plus riches en nourriture et moins acides.

Les écotypes des régions équatoriales sont donc, par leur adaptation à ce milieu, spécialement au facteur température et aux conditions de nourriture et d'acidité, condamnés à une croissance ralentie durant la plus importante partie de leur cycle de croissance.

L'apport complémentaire d'une nourriture artificielle aboutit éventuellement à une augmentation de la production totale mais ne peut, sans sélection contrôlée, accélérer la croissance de l'écotype, puisqu'il est adapté au milieu primitif et, par conséquent, génétiquement caractérisé par un métabolisme et une croissance ralentis.

Comme cette note intéresse directement la pisciculture de *Tilapia* spp., originaires du lac Moëro, on fut amené à discuter la répercussion des phénomènes d'adaptation sur la croissance d'autres écotypes de ces mêmes espèces. Remarquons que la technique utilisée peut être appliquée directement en vue de rechercher des formes adaptées à des conditions écologiques déterminées ou à introduire des espèces à caractère bien spécifique.

L'étude de l'influence d'autres conditions écologiques que la température peut se concevoir en appliquant les mêmes principes que ceux qui ont été suivis lors de l'étude de l'influence de la température. En effet, toute modification de la physiologie d'un organisme vivant se reflète dans l'évolution de ses phénomènes énergétiques.

Remarquons finalement que certaines conditions, non rencontrées dans le milieu habité par l'écotype, peuvent être favorables, si pas optima, et trouvées à l'aide de techniques semblabes à celles utilisées ici.

Ainsi trouve HEUTS (1947 b), pour chacune des populations de *Gastarasteus aculeatus* L., deux conditions de température et de salinité combinées qui sont optima et montre BROWN (1946 b) que la température optima pour l'utilisation efficiente de la nourriture (accroissement) est de 8°C chez *Salmo trutta* L. mais qu'un second optimum semble se situer dans les environs de 18°C.

L'étude expérimentale de l'adaptation physiologique peut donc, par les mesures des phénomènes énergétiques, aider l'hydrobiologie à connaître les espèces et leurs écotypes les mieux adaptés à un milieu donné, qu'il soit étang, lac ou rivière et cela, pour compléter l'exploitation de ces milieux.

Résumé

1° Le métabolisme d'entretien et d'activité ainsi que la consommation de nourriture sont mesurés en fonction de la température chez *T. melanopleura* et *T. macrochir*, originaires du lac Moëro.

L'interprétation des résultats a fourni les renseignements suivants:

a. La température optima pour l'accroissement est de 22°C environ chez *T. melanopleura* et de 23 à 24°C chez *T. macrochir*.

b. Les fluctuations constatées dans la consommation de nourriture en fonction de la température donnent des indications d'une valeur comparative pour l'alimentation en étang.

c. Le relantissement dans la croissance aux températures inférieures à 19°C et supérieures à 27—28°C a été expliqué.

d. Le mécanisme physiologique, qui limite la distribution de la population à des zones de températures fortement inférieures à la température léthale la plus élevée, a également été déduit des résultats.

2° Les phénomènes d'adaptation et leur répercussion sur la croissance des écotypes, qui habitent des eaux plus chaudes, plus acides et moins riches en éléments nutritifs que les écotypes des mêmes espèces mais originaires du lac Moëro, ont été discutés.

3° La méthode utilisée pour l'étude de la température optima peut servir, en principe, pour qualifier l'influence d'autres facteurs écologiques sur l'organisme.

Samenvatting

1° Het onderhoudsmetabolisme, het metabolisme bij normale activiteit en de voedselinname werden bij *T. melanopleura* en *T. macrochir* in functie van de temperatuur gemeten. Beide soorten waren afkomstig van het Moëro meer. De resultaten hebben de volgende inlichtingen verstrekt:

a. De optimale temperatuur voor groei is ongeveer 22°C bij *T. melanopleura* en 23—24°C bij *T. macrochir*.

b. De vastgestelde fluctuaties der voedselopname in functie van de temperatuur hebben een vergelijkbare waarde voor het bepalen der voedseltoediening in vijvers.

c. De groeivertraging, wanneer de uitwendige temperatuur beneden 19°C, daalt of 27—28°C, overschrijdt, werd verklaard.

d. Het feit dat de verspreiding van een populatie beperkt is tot temperaturen die ver beneden de hoogste lethale temperatuur liggen, werd verklaard door een fysiologisch mechanisme dat uit de bekomen resultaten kon afgeleid worden.

2° De adaptatieverschijnselen en hun invloed op de groei van ecotypen die warmere en armere biotopen bewonen dan de hier bestudeerde ecotypen van dezelfde soorten, werden besproken.

3° De methode gebruikt voor de studie van de optimale temperatuur condities kan in principe toegepast worden om de invloed van andere ecologische factoren te bepalen.

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Zoogeographical Review of the Black Sea Fish Fauna

by

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This paper is a condensation of my monograph 'The Fishes of the Black Sea Basin' published in Turkish. Since Turkish is a difficult language to get translated readily, we hope that European and American users of that work will be glad to have available this English summary.

Zoogeographically the basin of the Black Sea is the District of the Ponto-Caspian-Aral Province of the Mediterranean Subregion. The Mediterranean Subregion is characterized in general outline by the poverty of the species of the family Salmonidae and by the prevalence of species of the family Cyprinidae, and by the presence of genera which are strange to the circumpolar subregion. Also this subregion is related to Mississippian.

The Ponto-Caspian-Aral Province comprises the basins of the Black, Caspian, and Aral seas, with the exception of the upper and middle course of Amu-Darya and Syr-Darya, but including the Chu River, with Lake Issyk-kul; the rivers Ssary-Su, Nura, Turgai, and Irhiz; the Marmora Sea basin; and the northern part of the Aegean Sea, together with the rivers from Maritsa to Panaus in Thessaly.

The endemic genera of the Ponto-Caspian-Aral Province are *Caspiomyzon*, *Pseudoscaphirhynchus*, *Caspialosa*, *Clupeonella*, *Leucalburnus*, *Acanthalburnus*, *Capoetobrama*, *Percarina*, *Relictogobius*, *Proterorhinus*, *Caspiosoma*, *Benthophiloides*, and *Benthophilus*. These genera are remainders of the Upper Tertiary fauna, which lived in the interior waters located in the place of the recent Black and Caspian seas.

The genera that are common to the Ponto-Caspian-Aral and Mediterranean provinces are *Acipenser*, *Rutilus*, *Leuciscus*, *Chondrostoma*, *Barbus*, *Alburnus*, *Nemachilus*, *Lucioperca*, *Acerina*, etc. The Ponto-Caspian-Aral Province has also several relict genera for example *Umbra* (which occurs also in the North America and in the Danube and Dniester rivers); *Pseudoscaphirhynchus* (which also lives in the

Aral Sea and is closely related to the genus *Scaphirhynchus* of the Mississippi River system in northern America); *Aspiolucius* (which also lives in Tongking and in the Aral basin); *Misgurnus* (which occurs also in Europe in the Ponto-Caspian-Aral and Baltic provinces, in China, South Asia, Japan, and the Amur basin); and *Lucioperca marina* (which is related to American species of the genus *Stizostedion*). Besides in this province occur species with discontinuous distribution, which are absent in the interspace of Siberia, Turkestan and Central Asia but are present again in the Amur basin and in Manchuria, Korea, and Japan where they are represented by species that are closely related to those of our province, e.g., *Lampetra danfordi* and *Lampetra mariae* in the Far East are substituted by *Lampetra morii; Huso huso* is substituted by *Huso dauricus; Misgurnus fossilis* is substituted by *Misgurnus anguillicaudatus; Silurus glanis* is substituted by *Silurus soldatovi*, etc.

The relict character of the Ponto-Caspian-Aral Province is explained by the fact that during the Glacial Period the climate was somewhat milder than in northern lands. This circumstance enabled these species to survive the rigors of the Ice Age and later to spread more widely. Some species moved into the area from the north because of the approaching ice. This province is divided into three districts: (1) The Black Sea, covering the basins of the Black, Marmora, and Aegean seas; (2) the Caspian; and (3) the Aral. The following species are common to all three districts: *Acipenser nudiventris*, *Chalcalburnus chalcoides* and *Pungitius platygaster*.

The endemic forms of the Black Sea district, which is the subject of this investigation, are brackish-water fishes belonging to the genera *Percarina* and *Relictogobius* (*Percarina* seldom occurs in fresh water). The freshwater endemic species are: *Lampetra danfordi*, *Lampetra mariae*, *Hucho hucho* (which substitutes here for the Siberian species *Hucho taimen*, which is spread over some areas of the Volga, Kama and Pechora river systems, and also in Siberia), *Umbra krameri* (which lives in the Danube and Dniester rivers and which is akin to the North American species *Umbra limi* and *U. pygmea*, which are spread over the eastern United States), *Aspro zingel* (in the Danube and Dniester rivers), *Aspro streber* (in the Danube, Vardar and Dniester rivers), *Acerina acerina* (in the Dnieper, Dniester, Don and Kuban rivers), *Acerina schraetser* in the Danube, and *Mesogobius gymnotrachelus*.

Common with the Caspian district and not occurring elsewhere are the following species and genera: *Acipenser güldenstädti*, *A. stellatus* (which penetrates into the Adriatic Sea), the genus *Caspialosa* (which is closely related to the genus *Alosa* and is represented by different subspecies in the Black and Caspian seas), *Clupeonella delicatula*,

Rutilus frisii, *Lucioperca volgensis*, *L. marina*, some species belonging to the genera *Gobius*, *Caspiosoma*, *Benthophiloides*, *Benthophilus* and *Proterorhinus*.

In the Black Sea basin occur also species that are widespread in the circumpolar province (*Salmo trutta*, *Thymallus thymallus*, *Phoxinus percnurus*, and *Cottus poecilopus*). *Aphanius sophiae*, which is characteristic of the Iranian fauna, Syria, and the southern part of Asia Minor, occurs also in the systems of rivers of the Black Sea — Sakaria region and Kisil Irmak.

The fish fauna of the Black Sea basin, composed as a whole of the Mediterranean-Atlantic and Upper Tertiary fauna, is made up of 247 species and subspecies belonging to 123 genera and 57 families. Of the total 115 are marine, 98 freshwater, and 34 brackish-water.

The fauna of the Marmora Sea, including the freshwater forms occuring in the brackish waters, consists of about 200 species, of which approximately 135 are common with those of the Black Sea. But if we exclude 24 freshwater species only 111 common species remain. Of the Marmora Sea species 69 do not live in the Black Sea, except in the Bosporus area; therefore they may be included in the fauna composition of the Black Sea as rare visitors.

The fauna of the Aegean Sea contains about 100 species and subspecies of fish more than that of the Marmora Sea, i.e., it consists approximately of 300 species of which 120 species are common with the Black Sea. There are about 110 species common with the Azow Sea and with the Caspian about 50 ones.

As to the North Sea there are together with freshwater species about $\frac{1}{3}$ of their composition i.e., 80 species common with the Black Sea; common with the Baltic Sea about 70 species; with the Atlantic Ocean, without freshwater, about 100 species.

Comparing the marine Mediterranean-Atlantic fauna of the Black Sea with that of the Marmora Sea it is seen that in the latter in comparison with the first the following groups are represented by more numerous species: 1. *Plagiostomi* are represented here by about 20 species, while in the Black Sea only 5 species are known. These are represented by one or two species in each family. Flatfishes (B o t h i d a e, P l e u r o n e c t i d a e, S o l e i d a e) are represented also in the Marmora Sea by about 20 species, while in the Black Sea by only 7 species belonging to 4 genera occur. Then in the Marmora Sea there are more 7 species of L a b r i d a e, more 5 B l e n n i i d a e species, more 3 T r a c h i n i d a e species, more 2 M a e n i d a e species, more 4 S p a r i d a e species etc., but as it has been mentioned above most of the species which lack in the Black Sea visit the Bosporus region of the Black Sea. This circumstance has given us basis to include the Marmora Sea together with the western deap

part of the Black Sea into one area adjacent to the Bosporus. The same is observed when single groups of the Black Sea and Aegean Sea are compared. The difference observed between the Black Sea and the North Sea is expressed in prevailing in the first species of Acipenseridae, Percidae, Clupeidae, and from the Mediterranean groups — Labridae, Blenniidae, Syngnathidae and Sparidae. The similarity between these seas is expressed by the presence of common species belonging to the families- Squalidae, Rajidae, Trygonidae and Clupeidae and from the Mediterranean groups by some common species of the families Mugilidae, Scombridae, Triglidae and Gobiidae. Almost the some traits of similarity and difference are found also if we compare the fauna of the Black Sea with that of the Baltic Sea and the Atlantic Ocean, merely with the latter the Black Sea has more common species.

The general number of fish species in the Black Sea and Marmora Sea is nearly the same and the difference is expressed by the fact that the predominance in the Marmora Sea of the Mediterranean-Atlantic forms in some 69 species is substituted in the Black Sea by brackish or freshwater species. From the Aegean Sea has penetrated into the Black Sea more than $^1/_3$ of its fauna composition and from the Mediterranean Sea, in which according to TORTONESE (1938) there are 500 species belonging to 123 families, has penetrated about $^1/_5$ of its composition.

The species with a wider area distribution are common for all the seas. For instance about 50 species are common for the Black, Marmora, Aegean, Baltic, North seas and the Atlantic Ocean, i.e., approximately half of the Mediterranean-Atlantic forms which had penetrated into the Black Sea while the other half of them belongs to the species with a more limited distribution and is represented mostly by the Mediterranean endemics.

The fishfauna of the Black Sea basin consists according to SLASTENENKO (1936) of three groups:

1. **Freshwater** which by its origin is a Tertiary one hidden during the Glacial Period in the Caspian region and which during the Postglacial is spread step by step to the West after being accustomed to the waters of the Black Sea basin. This group consisting of freshwater and migratory fish reveals its relation to brackish waters to a different degree. So, some of them do not stand against the salinity, the other become adapted step by step to brackish waters and form an intermediate brackish-water group which is so clearly expressed in our basin. In all the river basins of the Black and Azow seas occur 155 species and subspecies of fish of various origin, from which about 98 species are freshwater ones. Among

these latter 40 species enter the brackish waters of the Black Sea and 34 ones those of the Azow Sea. The species number of fish in the basins of the rivers of the Black Sea decreases in the direction from West to East, what is explained on one side by the size of rivers, their character and by connection with other basins and on the other hand by historic causes which had taken place in the past. So, beginning from West we have the following picture: in the Danube River about 90 species, in the Dniester about 80 species, in the Dnieper 80 species, in South Bug about 75, in the Don 64, in the Kuban 64, in the Rion about 50; the rest small rivers have in their composition 20 to 25 species.

2. **Endemic,** so called Pontic relicts, which are remnants of the Upper Tertiary fauna consisting of 34 species. This group is also not uniform and it may be provisorily divided into 3 categories: a) Ponto-Caspian, b) Sarmatian, and c) Mediterranean origin elements to which belong some species of the families — Acipenseridae, Clupeidae, Gasterosteidae, Gobiidae etc.
3. **Mediterranean** consisting of 115 species of fish which penetrated from the Mediterranean into the Black Sea. From them 24 are represented in the Black Sea by peculiar species to which belong some species of the families-Clupeidae, Engraulidae, Belonidae, Gadidae, Syngnathidae, Atherinidae, Mullidae, Labridae, Blenniidae, Ammoditydae, Scorpaenidae, Bothidae and Pleuronectidae. This group may be called Tyrrhenian, for if we consider it as a separated one from the Mediterranean typical species, this evidently had taken place during the first Tyrrhenian period of increase in the salinity of the Black Sea waters. The rest of 91 Mediterranean-Atlantic species as to their origin are not uniform. So, a) here we have about 25 species of the Mediterranean endemics, i.e., $^1/_2$ of its composition in the Mediterranean Sea (according to TORTONESE, 1938 in the Mediterranean Sea there are about 50 endemic species) to which belong some species of the families Clupeidae, Syngnathidae, Atherinidae, Serranidae, Trachinidae, Labridae, Blenniidae, Clinidae, Callionymidae, Gobiidae and Gobiesocidae. Some of them are spread over the Atlantic Ocean, b) species reconciling their inhabiting as well in the Mediterranean Sea as in the Atlantic Ocean, for instance: *Nerophis ophidion*, *Syngnathus typhle*, *Engraulis encrasicholus*, *Squalus canicula*, *Sardina pilchardus*, species of the genera *Gobius*, *Trigla*, *Ammodytes*, *Squalus acanthias*, *Acipenser sturio*, *Sphyraena sphyraena*, *Sargus sargus*, *Raja clavata*, *Trygon pastinaca*,

Boops salpa, c) species living both in the Atlantic and Indian Ocean as *Sargus sargus*, *Trachinus draco*, *Lophius piscatorius*, *Zeus faber*, *Sardinella aurita*, d) species combining their residing in both the Atlantic and Pacific Ocean as *Atherina hepsetus*, *Trachurus trachurus*, *Conger conger*, *Sardinella aurita*, *Scomber scomber*, *Balistes capriscus*, and finaly, e) species living over all the three oceans as *Atherina hepsetus*, *Trachurus trachurus*, *Conger conger*, *Squalus fernandinus*. Common with Arctic Ocean are species: *Gasterosteus aculeatus*, *Pleuronectes flesus luscus*, *Lophius piscatorius*. Common with Red Sea are: *Morone labrax*, *Sciaena cirrosa*, *Mullus surmuletus*, *Serranus cabrilla*, *Sargus sargus*, *Trachinus draco*, *Lophius piscatorius* (according to TORTONESE, 1938, there are about 38 common species in Red Sea and Mediterranean Sea). Some species are cosmopolitan as *Lophius piscatorius*, *Conger conger*, *Mugil cephalus*, *Atherina hepsetus*, *Xiphias gladius*, *Thunnus thynnus*, *Trachurus trachurus*, *Naucrates ductor*, *Pomatomus saltatrix* and others. From occasional species in the Black Sea may be pointed out: *Squalus blainvillei*, *Merluccius merluccius*, *Sphyraena sphyraena*, *Naucrates ductor*, *Lichia amia*, *Dentex dentex*, *Boops salpa*, *Aurata aurata*, *Xiphias gladius*, *Morone labrax*, *Balistes capriscus* and others. Some species have amphiboreal or bipolar distribution (see BERG, 1933, TORTONESE, 1938). Among the boreal forms in the Black Sea may be noted: *Squalus acanthias*, *Scyliorhinus canicula*, *Trygon pastinaca*, *Sardina pilchardus*, *Engraulis encrasicholus*, *Syngnathus typhle*, *Raja clavata;* some species of the genera: *Gobius*, *Blennius*, *Nerophis*, *Spratella*, *Bothus*, *Pleuronectes* and others.

As it is seen the fauna of the Mediterranean subregion has a mixed character consisting of the ancient endemic thermophile and moderate Atlantic forms with admixture of species from Indian, Pacific or North Arctic Ocean or with a wide distribution area.

From 57 families represented in the Black Sea 11 comprise freshwater species as follows: Petromyzonidae, Salmonidae, Thymallidae, Umbridae, Esocidae, Cyprinidae, Cyprinodontidae, Cobitidae, Siluridae, Percidae, Cottidae. Two families are represented by brackish water species as: Acipenseridae and Clupeidae. Two families Gobiidae and Gasterosteidae comprise species of all three categories, i.e., marine, brackish and freshwater ones. The rest, 42 families consisting of marine species, one can divide into the following categories: a) families confined in their distribution area by Mediterranean Sea and Atlantic Ocean (part of which are Mediterranean endemic) as: Sphyraenidee, Atherinidae, Mugilidae, Serranidae, Mullidae, Sparidae, Maenidae, Poma-

centridae, Labridae, Gobiidae, Scorpaenidae, Trachinidae, Blenniidae, Syngnathidae, Gobiesocidae; b) — distributed in the tropical region: Serranidae, Sciaenidae, Mullidae, Pomacentridae, Labridae, Callionymidae, Scorpaenidae, Balistidae; c) — families of boreal character: Triglidae, Ammodytidae, Squalidae and d) — cosmopolite: Xiphiidae, Thunnidae, Scombridae, Lophiidae, Trachinidae, Pomatomidae and Congridae.

On the basis of the distribution of freshwater fishes BERG (1933) divides the Black Sea district into three zoogeographic freshwater areas: 1. Danubian-Kuban, 2. North-Aegean and 3. Kolchic-Anatolic. Zoogeographic review of the freshwater fish fauna of Turkey is done in the paper of KOSSWIG & BATTALGIL (1942).

On the basis of the distribution of marine, brackish and freshwater fish and analysis of their life conditions we divide the Black Sea faunistic district into 5 following marine sections and 8 freshwater areas (see SLASTENENKO, 1955—1956, p. 654); to each marine section correspond its adjacing freshwater areas, so:

I. Odessa or North- West marine section, embracing the whole north-west shallow part of the Black Sea, the south border of which is the line about Sebastopol-Varna. This section is characterized by the mixed type of the fauna Pontic, freshwater and Mediterranean-Atlantic one.

Among endemic forms the characteristic here are: *Percarina demidoffi*, *Lucioperca marina*, *Benthophiloides brauneri* (two latter are common with Caspian Sea), *Acerina schaetser*, *Gobius kessleri*; also are characteristic local forms as follows: *Rutilus rutilus heckeli*, some forms of the genus *Caspialosa*; among marine ones *Caspialosa bulgarica*, *Lichia amia* and other marine forms unknown in other sections. Near to this marine section are located two freshwater areas: Danubian-Dniester and Dnieper-Bug.

1. Danubian-Dniester freshwater area embraces the basin of the Dnieper and Dniester rivers populated by more than 80 fish species. Characteristic for this area is the presence of endemic forms as: *Gobio kessleri*, *Gobio uranoscopus*, *Acerina schraetser*, *Aspro streber*, *Aspro zingel*, *Umbra krameri* and common with other European areas as: *Gobius kessleri*, *Barbus barbus*, *Barbus meridionalis petenyi*, *Cottus poecilopus*, *Percarina demidoffi*, *Coregonus lavaretus*, *Thymallus thymallus*, *Salvelinus alpinus*, *Lampetra danfordi*, *Lampetra mariae*, *Lampetra fluviatilis*, relict form *Hucho hucho*. In the upper parts of Danube occur also peculiar subspecies as: *Rutilus frisii meidinger*, *Chalcalburnus chalcoides mento*, *Vimba vimba elongata*. As it is seen this area gets into a close touch with European fauna, but

the presence, in it only, of such species as *Umbra krameri*, *Hucho hucho* and others point out the abscence of a close connection of rivers of the Black Sea and, due to certain isolation and direct influence of glacial waters, here survived species which were not preserved in the other sections of the basin. Here are absent the following genera-*Varicorhinus* and *Aphanius*, as in all other areas of the Black Sea basin, besides Kolchic-Anatolic and among the Asiatic genera are absent-*Schizotorax*, *Acanthorutilus*, *Hemigrammacapoeta* and also some species characteristic for other sections.

2. Dnieper-Bug freshwater area embracing the basins of the Dnieper and South Bug rivers which are populated by about 80 species. It is characterized by the absence of endemic species (with exception perhaps of *Gobio belingi*) of the Danubian-Dniester area as e.g. representatives of genera: *Aspro*, *Hucho*, *Umbra*, *Gobio kessleri* and other species and some representatives of the fauna of neighboring eastern or western areas as: *Varicorhinus*, *Cottus*, *Coregonus*, *Thymallus* and other points out the circumstance that the endemic fauna of this area disappeared at the Glacial time and during the last Black Sea phase it did not succeed or could not spread here from the neighboring sections.

II. The section of the Azow Sea embraces the Sea of Azov and the coastal region of the Black Sea within the sphere of influence of the Kerch Strait. It is characterized by the presence of peculiar species or subspecies as: *Scophthalmus torosus*, *Percarina demidoffi maeotica*, *Rutilus rutilus heckeli* (common with Odessa section), *Syngnathus nigrolineatus maeoticus*, *Benthophilus macrocephalus magistri*. In this section occur up to 128 species and subspecies of fish and closely adjacent to it are two freshwater areas: Don and Kuban-Crimean.

3. Don freshwater area embracing the basin of the Don River is characterized by the absence of the genus *Barbus* which is however known in the neighboring sections, genera *Aspro*, *Hucho*, *Umbra*, *Varicorhinus*, and by the absence of endemic forms with exception perhaps of *Leuciscus danilewski*, which is pointed out also for the upper Dnieper, and *Gobio albyi*. We observe here the same phenomenon as in the Dnieper-Bug freshwater area, where because of the loss of Sarmatian and Quaternary elements at the Glacial time the fauna of the area is populated by the species which did not succeed to get of their own forms or to receive species from the neighboring sections.

4. Kuban-Crimean freshwater area embraces the basin of the Kuban River, the small rivers of North Caucasus and Crimea. It is characterized by the presence of peculiar subspecies which are close to the typical species of neighboring areas and are in many

things under the influence of the Caucasus fauna. So the following species are here characteristic: *Leuciscus cephalus orientalis*, *Chondrostoma colchicum kubanicum*, *Gobio ciscaucasicus*, *Barbus tauricus kubanicus*, *Cobitis caucasica*. For this area are endemic: *Clupeonella abrau* (synonym of which is *C. muhlisi)*, *Relictogobius kryzanovski* and *Leuciscus aphipsi*. Here are absent the species: *Gobio kessleri*, *Lota lota*, *Thymallus thymallus* and other, mainly, endemics of other section but *Lampetra mariae* occurs.

The Crimean fauna is extremely poor and on the one side it is close to the fauna of the Western Caucasus and of the Black Sea coast of Asia Minor and on the other side to the fauna of the Bulgarian rivers discharging into the Black Sea. All Crimean species with exception of *Nemachilus barbatulus* and *Cottus gobio*, occur in Western Transcaucasus and they are replaced by corresponding subspecies as: *Leuciscus cephalus orientalis*, *Phoxinus phoxinus colchicus*, *Gobio gobio lepidolaemus* n. *caucasicus*, *Barbus tauricus escherichi* and others. The Crimean freshwater fauna consists of about 25 species. There is no one endemic species in the Crimea because *Barbus tauricus* properly speaking, as it pointed out by BERG, is a subspecies of *Barbus escherichi*, which occurs in Western Transcaucasus and Asia Minor. Besides in Kuban lives a closely related form *Barbus tauricus kubanicus*. There is neither in the Crimea nor in Transcaucasus the genus *Varicorhinus*.

III. Caucasian marine section embraces the eastern half of the proper Black Sea, the border of which is approximately the line in the north from the south tip of the Crimea and to the south approximately to Sinop on the Anatolia coast. Here are characteristic the peculiar forms: *Caspialosa tanaica palaeostomi*, *Blennius ponticus*, *Ammodytes cicerellus bergianus*, *Atherina bonaparti*; among marine species along the coast of Anatolia, here penetrate species which are rare for the Black Sea: *Merluccius merluccius*, *Callionymus lyra*?, *Boops salpa*, *Balistes capriscus* and others. Adjacent to this marine section, partially coming out from its limits is the freshwater area:

5. Colchic-Anatolian freshwater area, the borders of which extend from the Rion River in the East, along the Anatolian coast, to the border line of the distribution of the genus *Varicorhinus* i.e., about to Brussy area in the West. It is characterized by the presence of the genera: *Varicorhinus*-*V. sieboldi*, *V. tinca*, *V. damascinus*; *Aphanius*-*A. sophiae*, *A. chantrei*; *Leuciscus lepidus*, *Chondrostoma regium*, *Alburnus escherichi* (Angora), *Cobitis simplicispina* (in the Sakaria basin), *Nemachilus lendli* from Angora, which are absent in all above mentioned areas. The fauna of the area consists of about 60 Sarmatian-European species with admixture of Asiatic ones.

IV. Bosporus marine section embraces the western half of the proper Black Sea, Bosporus and the Sea of Marmora with the Mediterranean marine fauna and admixture of Sarmatian species totally about 200. Characteristical for this section is the absence of endemic species. The environmental conditions of the fauna of the South-Western part of the Black Sea are more close to those of the Sea of Marmora than to its Eastern half. Here occur rare forms which are known only in this section of the Black Sea, e.g., *Scophthalmus ponticus*, *Trigla cuculus*, *Blennius ocellaris*, *Sargus sargus*, *Coris julis*, *Scomber japonicus* and others. In the Marmora Sea occur approximately 69 fish species more than in the Black Sea, which do not penetrate far into the Black Sea being limited to sporadic occurence at Bosporus. (One may also separate a special Crimea marine section embracing the coasts of the Crimean peninsula, essentially with the fauna of Mediterranean origin. Only here are known the following species: *Blennius knipowitschi*, and with a limited distribution the species: *Labrus viridis prasostictes*, *Sphyraena sphyraena*, *Blennius ocellaris*, *Tripterygion tripteronotus* and others). The freshwater fish fauna which is limited to the coast of the Marmora Sea and its Straits and to the part of the coasts of the Black Sea adjacent to Bosporus i.e., to the contact of it with Colchic-Anatolian and Danubian-Dniester freshwater areas, we separate as Bosporus freshwater area:

6. Bosporus freshwater area is characterized by the mixed European-Sarmatian fauna, including about 50 species and subspecies, about 35 species from them in the fresh waters of the area and the rest occur also in the Marmora Sea. Besides here live representatives of the genus *Phoxinellus*, *Alburnus albidus*, *Rutilus rubilio*, *Leuciscus cephaloides*, *Phoxinus phoxinus colchicus* and some species are represented by peculiar forms e.g.: *Leuciscus cephalus cephalopsis*, *Barbus tauricus oligolepis (polylepis, cyclolepis)*, *Caspialosa tanaica etemi*, *Salmo trutta macrostygma* and others. The fauna of this section is considered in details in the paper of Kosswig (1942).

V. Aegean marine section embracing the area of the Aegean Sea with typical Mediterranean-Atlantic fauna and with admixture of south and north and also Sarmatian species, totally about up to 300. Out of the borders of the Aegean Sea, the Mediterranean Sea was not influenced by the fauna of the Black Sea in the past nor at present time. The freshwater fauna of this section is considered by us preliminary mainly merely in the area of the rivers discharging into the north and eastern part of the Aegean Sea; we separate here two freshwater areas: North-Aegean and that of Asia Minor embracing the Aegean coast of Asia Minor approximately to the area of Izmir (Smirna) which is studied in details in the paper of Kosswig &

BATTALGIL (1942). The freshwater fauna of Greece is out of our scope. See about this the paper SCHMIDT RIES „Die Fische Griechenlands". Zeitschrift für Fischerei B. 42. H. 3, 1943.

7. North-Aegean freshwater area embracing the basins of the rivers discharging into the Aegean Sea from the north e.g.: Maritsa, Mesta, Struma and also Vardar, the fauna of which is considered to be a poor fauna of Danube with exception of the endemic form characteristic for Vardar e.g. *Pseudophoxinus macedonicus*; in other respects here are European species with admixture of Sarmatian ones which penetrated at recent Black Sea time e.g.: *Acipenser stellatus*, *Huso huso*, *Proterorhinus marmoratus* and others.

8. Asia Minor freshwater area embracing the Asia Minor coast of Aegean Sea, approximately to the Izmir area. It is characterized by endemic species e.g.: *Aphanius danfordi*, *Barbus lydianus*, *Varicorhinus holmwoodi*, and also by the presence of some European-Sarmatian species as: *Chondrostoma regium*, *Leuciscus borysthenicus smyrnaeus*, *Rhodeus sericeus*, *Alburnoides bipunctatus*, *Leuciscus berak*, *Alburnus escherichi* and others.

After investigations of KOSSWIG it became evident, that European and Asia Minor coasts of the Aegean Sea are not much isolated with respect to faunistic conditions. Generally the freshwater fauna extend from one side from the East to West, along the northern and less along the southern coasts of the Black Sea and from the other from the European mainland to the Eastern coast of Asia Minor.

We divide the Black Sea district into two subdistricts:

I. Euxine embracing the marine sections of the Sea of Azov and those of Odessa with adjacent freshwater areas and also the northern coasts of the Aegean and of Marmora seas of which the community of fauna was evidently more expressed in the past. Here we have influence of the Upper Tertiary fauna, which in the past, because of the absence of a connection with Mediterranean Sea dominated over the elements of European fauna.

II. Black Sea subdistrict embracing Caucasian, Bosporus and Aegean marine sections with Mediterranean-Atlantic fauna, being essentially with respect to the fauna a part of Mediterranean Sea. The admixture of Sarmatian forms in the basins of rivers of this subdistrict does not change its substance. Here is observed a gradual decrease of Sarmatian forms from the East to the West and vice verse of those Mediterranean-Atlantic.

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Description of a community of microorganisms in purified sewage mixed with rain water from storm-sewers

(A method for the determination of micro-biocoenoses)

by

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Observation post

A large part of the western section of Amsterdam city has a separate sewerage system which provides sewers that carry rainwater polluted with street refuse to surface water and sewers that carry domestic and industrial waste waters to a sewage purification plant. In this plant the water is treated biologically i.e. the wastes are mineralized by bacteriological fermentation and oxidation. Sedimentary matter in the sewage is processed by fermentation; suspended, colloidal and dissolved substances in the sewage water are processed by oxidation.

Those wastes, occuring in the three just mentioned physical forms include together with the water, the greatest mass of sewage, discharged on the surface water after purification. The installations where the waste substances of the western section of Amsterdam city are treated, officially bear the name of „Rioolwaterzuiveringsinrichting West" (Sewage-purification-plant West).

The purified sewage of this plant flows out into the „Erasmusgracht" since 1951. Moreover rain-water, polluted with street refuse from that part of the town, is carried to this „gracht" (canal) by the so-called storm-sewers.

Until January 1955, the water in this „gracht" was kept on a level of c. 2.10 m — N.A.P. by a pumping installation, situated at

a distance of 1500 m from the outlet of purified sewage, that pumped the water from the „Erasmusgracht" into the town basin (Level: c. 0.45, — N.A.P.)[1]). The result was that in the course of time the „Erasmusgracht" was almost exclusively filled with a mixture of purified sewage from the plant and rainwater from the storm-sewers.

During 1955 the earthen walls, that gave this „gracht" its ditchlike character, were replaced by stone walls and in the same year the level of the water was gradually put up to 1.30 m — N.A.P. As the „gracht" was also widened, deepened and carried a bigger load of water after the fill-up, it now possessed the characteristics of a canal.

In January 1956, the pumping that directed the water to the town basin was stopped and this, combined with the outflow of the storm-sewers and the effluent of the purification plant, caused such an increase in the quantity of water in the „Erasmusgracht" that it rose to town level.

The canal and the town basin were connected by taking away the barrages between them; a constant movement of the water towards the town basin however was left. In rebuilding the canal the depth of the water changed from c. 1.50 to c. 3 m. As the distance between the walls was doubled, the mass of water increased by four.

The investigation of micro-organisms

From January 1953 until December 1958 samples were regularly taken at the same spot, ca. 750 m from the outlet of the effluent of the purification plant, in order to know the kinds of plankton and other micro-organisms suspended in the water.

In taking observations, 20—26 times per year, two different ways of sampling were used: 1 l of water was scooped immediately from the canal and 3 ml of a 40 % solution of formol was added on the spot, while another 10 l were taken out in a bucket and these 10 l were passed through a fine-mesh silk net. The residuum of c. 100 ml that remained in the net was also fixed by adding formol. The 1 l sample as well as the c. 100 ml residuum out of the 10 l sample were put in tall and rather narrow bottles, which stood for a week at least, giving the concentrated organisms a chance to settle. Then the clear liquid on top was carefully drawn off by a siphon. If a sufficient quantity of liquid could not be taken off, the remainder

[1]) N.A.P = watermark zero
+ means: meters above this mark
— means: meters below this mark
The water level 0.45 m—N.A.P. is therefore higher than the water level 1.30 m—N.A.P.

was shaken and again left to settle in a glass cylinder. During the time of settling, bottles and tubes were sometimes moved to and fro rotating around the longitudinal axis to remove substances from the vertical glass wall and make them sink to the bottom. Substances that kept floating were separately examined under the microscope finally. The concentrated sediment was put in centrifugal tubes and after centrifugation there usually was a volume left that, including the liquid, with the aid of a pipet could be reduced to 2 ml. It seldom happened that 4 ml had to be left in the tubes because a greater volume remained after centrifugation.

In this way we attained the following rates of concentration of micro-organisms; c. 500 times in the case of the 1 l sample and c. 5000 times in the case of the 10 l sample, from which the greater part of very tiny organisms escaped through the meshes of the silk net.

Before the microscopic examination the samples, both reduced to a volume of 2 ml, were mixed very thoroughly and one drop (1/25 th of the mixture) was put on an object glass and covered with a cover glass. The varieties of micro-organisms, present in this drop, were noted down during the microscopic examination, done with the aid of a mechanical stage. Empty shells of diatoms and remains of organisms already dead before fixation, were not listed.

Grouping of collected data on micro-organisms

The species found during one calender-year were put on a list, headed by the dates of sample-taking. The species, present in the 1 l sample and 10 l sample of the same day, were recorded in this list. This made it possible to follow the dates of the observation-year when each species was found.

An example of this way of grouping follows here:

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Nov	Dec
e of 1 l	x	x	x		x	x	x	x	x		x	x	x		x	x	x	x	x			x
nism 10 l		x		x	x	x	x		x	x	x	x		x	x	x	x			x	x	x
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

It is clear that the organism was found 22 times; in the 1 l sample, in the 10 l sample or in both. This means a presence of 22/26 or 84 %, as samples were taken on 26 days of the year. The percentages found in this way were valued as follows:

80 — 100 %	= 5	20 — 39 %	= 2
60 — 79 %	= 4	< 20 %	= 1
40 — 59 %	= 3		

The importance of the numbers in which micro-organisms are present

Micro-organisms are spread easily. The rule „Everything is everywhere, but presence is actually dependent on environmental situations" could be applied to these living beings. According as an organism feels at home better in a body of water chances are greater, that it is always found alive in the same spot.

Besides the organisms that feel completely at home in the environment, there will be others that can just bear the situation they are in. The latter do not really take root and appear in such small numbers in the course of a year, that they are hardly noticed in the examination. They rank low in presence.

Moreover, organisms from other sources, that are in communication with the water body, can be lead in. If organisms are brought in again and again, the surrounding waters that add to the water at a fixed spot need a study of their micro-biological population.

Waters from different sources, however, often do not mix well and so the balance of the population at the observation post may be kept when a mixing of different groups of species would be possible. The organisms, that can just bear the situation, become a minority but if they do not fit in at all, they die.

The biological community in a given spot will give rise to a picture characteristic of that same spot. For studying the association of the streaming watercourses it is necessary to involve in inquiry more observationplaces, situated on greater or smaller distances from each other.

The community, belonging to the whole watercourse, is to determine from the obtained values in presence.

Each observationplace can however show beside more particular species.

The numbers given to the percentages serve to measure the coupling of micro-organisms in the community. If organisms continuously just can bear the circumstances in which they move, they rank low in presence. The species, holding their own in such large numbers that they are noticed in every microscopic examination, rank high in presence. These fit best in the environment.

The species reaching the figures 4 and 5 make the picture of the micro-biocoenosis characteristic of the place of observation. If a larger number of species get these high marks the place of observation is better charaterized. This is also in force for the bigger spaces of water, where on more observation places at the same time, an inquiry after the species in presence is involved. The species, that reach a high value at all the spots, charaterize the whole territory.

It may be assumed that the conditions of the environment have not changed, if the same community with the same species reaching high marks, is found year upon year. The organisms that compose those species structure obviously find favourable conditions. They charaterize the environment, although each variety need not be large in number, in every sample. The community is not determined by the picture of a given moment.

Organisms, dependent on seasonal conditions, do not get high marks of course. They would not have been listed as members of the community if percentages indicated by 3 were not taken into account; organisms that do not bear up so well to the environmental conditions are also indicated by 3. If the latter however are found in other places near the place of observation under the same meteorological conditions the whole year round, it may be assumed that they really find conditions less favourable. Their chances are nearly as good as those for the species that are always found together.

The organisms that get the figures 1 and 2 only have a chance of becoming a member of the community if the environment changes. They cannot be called characteristic for the association although they might be present in large numbers for a short time.

The more the environment changes, the more the number of species with a low figure will increase and the more the number of species with a high figure will be small.

Stray species

Besides the organisms of the upper strata (plankton) the bottom-dwelling and sessile organisms may be mentioned in the series found in the samples. In low water the bottom-organisms may be stirred up and swept into suspension. Heavy traffic or strong current may keep also bottom forms in suspension and loosen sessile organisms. If these stray species reach a high figure, they also define the place of observation and indicate a factor, characteristic of the environment.

Comment on the presence of organisms expressed in figures

In the description of the alterations made in the Erasmusgracht during the time of observation, we see that a few periods on these years are important. From 1953 up to and including 1954 the level of the water was low. In 1955 the level was put up a little but in 1956 it started to rise to a far higher level. At the place of observation the water in the canal consisted for the greater part of purified sewage, rain water and street refuse.

The following table shows the masses of water released by the water purification plant, and gives an impression of the quantities of effluent that flowed into the canal.
Effluent from the „Sewage Purification Plant West”

1953	c. 4.000.000 m^3
1954	c. 5.000.000 „
1955	c. 5.500.000 „
1956	6.481.400 „
1957	7.482.500 „
1958	8.757.600 „

(Data from the dept. Sewerage and Water Sanitation Dept. of the municipal Board of Works and Public Buildings, Amsterdam).

For the first period of 3 years broad figures could only be given but the quantities of effluent were measured from 1956 on. The volume of water in the canal measures c. 180.000 m^3 between the point of outflow from the plant and the point of connection with the town basin, so it will be clear that the water in the canal is replaced by fresh purified sewage in a very short time when a quantity of c. 20.000 m^3 effluent flows in per day.

When it rains the outflow of the storm sewers add to the volume in the canal. In the following table you will find the amount of rain per year as measured by the Amsterdam Station of the Royal Netherlands Meteorological Institute.

Rainfall	in mm
1953	611
1954	966
1955	742
1956	823
1957	907
1958	919

In the observation period there was a dry year when the water level was low (1953) and a wet year when the water level was high (1954). In 1955 and 1956, during which the level of the water rose, the amount of rain was average and in the two following years above average.

Looking at the figures in the next table, representing the presence of micro-organisms in the canal; the following is remarked:

A number of genera and species are found in such numbers in every examination, in spite of the changing conditions of the environment, that they make a basis-community. They are: *Oscillatoria*, *Ankistrodesmus falcatus*, *Ankistrodesmus falcatus mirabilis*, *Scenedesmus obliquus*, *Scenedesmus quadricauda*, *Cyclotella*, *Gomphone-*

ma, *Navicula*, *Nitzschia*, *Phacus caudatus*, Ciliates under which *Vorticella*.

Besides these forms, there were a number of species present in the first few years — when space was small and water at a rather low level — that did not reach 3 or a higher figure when the water rose to the highest level mentioned. They are: *Dactylococcopsis*, *Protococcus*, *Navicula cuspidata*, *Navicula rhynchocephala*, *Pinnularia*, *Euglena spirogyra*, *Phacus agilis*, *Phacus pyrum* and *Trachelomonas hispida*.

In the last three years when the body of water was bigger and the water at its higher level, the following species came to the front by reaching a higher figure: *Actinastrum hantzschii*, *Ankistrodesmus acicularis*, *Pediastrum duplex*, *Asterionella formosa*, *Melosira granulata*, *Chlamydomonas*, *Chrysococcus biporus*, *Brachionus angularis*, *Brachionus calicyflorus*, *Keratella quadrata*, *Daphne longispina*, *Chydorus sphaericus*, *Lepocinclis texta*, *Dictyosphaerium ehrenbergianum*, *Richteriella botryoïdes*, *Characium limneticum*, *Schroederia*, *Diatoma elongatum*, *Rotifer* and *Bosmina*.

The behaviour of Euglenophyceae and a few others is most remarkable. These decreased in number in 1956, were lowest in 1957, but increased again in 1958. The following species show this trend: *Fusarium*, *Closterium acerosum*, *Euglena acus*, *Euglena oxyuris*, *Euglena variabilis*, *Phacus acuminatus*, *Phacus alatus*, *Phacus caudatus*, *Phacus parvulus*, *Phacus pleuronectes*, *Trachelomonas volvocina* and Nematodae.

To divide organisms in those belonging to the population and others that are less important, the figures 3, 4 and 5 are in bold type in the table.

The bacteriological examination

The examination on faecal pollution of the water included the Eijkman test at 45°C and the determination of faecal streptococci.

The samples for bacteriological, chemical and plankton examination were taken at the same time.

An average of the faecal pollution per year was obtained by putting the yearly figures in one group. The number of positive results of the Eijkman test for each inquired quantity of water of a certain year were expressed in a percentage of the total number of samples Eijkman tests made per year. These figures are found in the next table. They show the percentages of positive results in the 10 ml and 1 ml water of the samples etc. The same was done with the streptococci titers.

Eijkman Test at 45°C.
Percentages of the number of positive results against the total number of tests.

	10 ml	1 ml	0.1 ml	0.01 ml	0.001 ml	0.0001 ml
1953	100	100	99	99	85	39
1954	100	100	99	95	68	22
1955	100	100	100	91	43	18
1956	100	100	93	74	31	7
1957	100	100	92	58	16	6
1958	100	100	93	83	33	10

Streptococci Test at 45°C.
Percentages of the number of positive results against the total number of tests.

	10 ml	1 ml	0.1 ml	0.01 ml
1953	100	100	98	73
1954	100	94	86	40
1955	100	98	84	52
1956	100	88	62	17
1957	100	94	50	12
1958	100	90	60	20

Both series show a decrease in faecal pollution during 1953 up to and including 1957. In 1956 and 1957 faecal pollution was lowest but increases again in 1958.

Chemical examination

To determine the substances present at the moment of plankton sampling the necessary quantities of water were taken at the same time.

The methods used for the several determinations are described in „Standard Methods for the Examination of Water and Sewage".

The percentage of the biochemical use of oxygen in 24 hours at 20°C. for the original water sample was calculated against the quantity of oxygen present in the original sample.

In connection with the kind of examination the results of test of each substance were added up per year and divided by the total number of samples, thus determining an average; maximum, minimum and average per year are given in the table.

Chemical results.

mg/l	Year	Minimum	Maximum	Average
Total Dissolved Residue	1953	822	1470	980
	1954	577	2007	884
	1955	706	1268	847
	1956	642	935	815
	1957	696	1867	857
	1958	652	890	792
Loss on ignition	1953	57	1025	162
	1954	13	605	102
	1955	8	330	88
	1956	30	178	68
	1957	27	135	65
	1958	11	110	48
$KMnO_4$ used up	1953	50	96	67
	1954	44	82	59
	1955	45	93	62
	1956	47	108	61
	1957	23	70	58
	1958	52	77	61
Chloride	1953	160	320	213
	1954	120	205	168
	1955	155	210	177
	1956	155	225	183
	1957	150	295	183
	1958	160	190	172
Nitrite	1953	mark	23.9	3.7
	1954	0.2	2.7	1.2
	1955	0.4	4.1	1.6
	1956	0.4	3.0	1.8
	1957	0.8	5.0	2.6
	1958	0.4	7.8	3.0
Nitrate	1953	2.0	88.8	26.5
	1954	13.2	88.8	42.6
	1955	0.9	66.6	35.5
	1956	1.0	44.2	21.2
	1957	1.4	42.2	14.1
	1958	0.8	3.9	2.0
Sulfate	1953	16	292	70
	1954	13	202	86
	1955	26	132	58
	1956	41	122	86
	1957	25	417	88
	1958	61	107	82

mg/l	Year	Minimum	Maximum	Average
HCO_3	1953	241	875	523
	1954	176	678	456
	1955	172	620	387
	1956	186	518	400
	1957	211	470	335
	1958	453	600	511
CO_2	1953	7.5	39.8	18.9
	1954	9.0	39.0	24.2
	1955	8.0	72.0	25.8
	1956	5.0	44.6	21.5
	1957	8.5	63.0	35.9
	1958	12.0	55.0	34.8
Phosphate in gamma/l	1953	102	3067	1031
	1954	150	4140	862
	1955	165	3750	1278
	1956	162	1666	653
	1957	195	1500	653
	1958	156	1579	650
SiO_2	1953	0	36	21
	1954	1	65	21
	1955	6	44	26
	1956	8	75	38
	1957	7	110	36
	1958	13	45	28
H_2S	not found in the examination			
NH_4saline	1953	mark	14.5	2.6
	1954	mark	11.9	1.5
	1955	0	13.7	0.9
	1956	0.1	0.5	0.1
	1957	0.1	8.1	0.8
	1958	0.1	2.5	0.3
NH_4 albuminoid	1953	0.8	35.6	15.8
	1954	0.3	21.7	5.6
	1955	0.1	16.2	6.3
	1956	0.3	11.2	5.6
	1957	0.1	7.5	2.2
	1958	1.0	8.1	4.5
Iron	1953	0.15	0.5	0.33
	1954	0.15	0.7	0.38
	1955	0.1	0.5	0.35
	1956	0.1	0.7	0.27
	1957	0.1	0.3	0.16
	1958	0.2	0.3	0.27

mg/l	Year	Minimum	Maximum	Average
CaO	1953	113	263	144
	1954	114	299	170
	1955	86	286	162
	1956	83	191	132
	1957	47	176	136
	1958	78	222	152
MgO	1953	29	102	57
	1954	28	117	62
	1955	14	185	65
	1956	10	92	45
	1957	15	132	49
	1958	15	358	76
Kalium	1953	2	12	7
	1954	0	8	1
	1955	0	16	8
	1956	4	12	9
	1957	0	10	2
	1958	0	1	<1
Oxygen	1953	0.8	9.2	3.9
	1954	1.4	8.4	4.6
	1955	1.0	8.9	3.9
	1956	1.4	15.3	5.9
	1957	2.3	10.5	6.0
	1958	1.0	15.7	4.9
Percentage of Oxygen saturation	1953	8	69	34
	1954	16	79	42
	1955	11	74	34
	1956	15	137	54
	1957	19	112	56
	1958	9	167	47
Percentage of use up of oxygen	1953	15	91	62
	1954	32	89	66
	1955	0	87	47
	1956	13	74	38
	1957	2	77	32
	1958	3	74	44
Total hardness in German degrees	1953	16.1	28.1	22.6
	1954	18.2	39.9	25.6
	1955	11.8	39.6	25.2
	1956	8.5	27.2	20.4
	1957	10.4	35.7	20.7
	1958	13.4	67.0	25.6

mg/1	Year	Minimum	Maximum	Average
Bicarbonate hardness in German degrees	1953	11.0	40.0	24.0
	1954	8.1	31.2	20.9
	1955	9.7	33.6	19.3
	1956	8.5	23.4	18.2
	1957	9.7	21.8	15.4
	1958	15.5	27.6	23.4
pH	1953	7.4	8.0	7.7
	1954	7.1	7.7	7.4
	1955	7.1	7.7	7.44
	1956	7.4	7.9	7.7
	1957	7.6	7.9	7.74
	1958	7.4	7.9	7.64

The average chemical results show that great differences in the percentage of chloride did not occur during the 6 years of observation. When the water rose to its high level, the percentage of nitrate went down. The quantities of phosphate showed a sharp decline in the last three years.

According to an information of the chemical bacteriologist of the Sewage Purification Plant West (Dr. H. v. d. Zee), the percentage of nitrate in the effluent in 1958 amounted to average 80 mg/l.

The figures on SiO_2, O_2, use up of O_2 and hardness with the allied figures of CaO and MgO show a remarkable trend. In 1956 and 1957 they are subject to clearly perceptible changes and in 1958 they return more or less to the figures of the first 3 years.

Comparison of the chemical, bacteriological and biological methods used in the examination.

The results gained in the examination by these different methods clearly show a connection with the temporary changes in the environment under observation.

In 1956 and 1957 the degree of pollution of the water of the Erasmusgracht is lowest according to the chemical and bacteriological results and this coincides with a decrease in presence of Euglenophyceae and a few other organisms.

It appears that the use of average in an examination of a body of waters offers possibilities to compare results of different origins.

May the utility of this method of examination be further tested. The examination of the association between micro-organisms in water leaves much to be desired and this justifies to use methods that have not been tried before.

TABLE OF PRESENCE OF MICRO-ORGANISMS, EXPRESSED IN FIGURES

Name of the organism	1953	1954	1955	1956	1957	1958
Fungi						
Asterothrix raphioides (REINSCH) PRINTZ	1	2	1	1	1	1
Fusarium spec.	**3**	**3**	**3**	2	2	**3**
Cyanophyceae						
Anabaena spec.	1	1	0	0	0	1
Aphanizomenon flos aquae (L.) RALFS	1	2	2	0	1	1
Aphanocapsa spec.	**3**	2	2	1	1	2
Aphanothece spec.	1	0	1	0	0	1
Chroococcus limneticus LEMM.	1	1	1	0	0	0
Chroococcus spec.	**3**	2	0	0	0	1
Coelosphaerium kutzingianum NÄG.	1	0	0	0	0	1
Cyanophyceae in thin threads	**4**	**3**	**3**	2	1	2
Dactylococcopsis spec.	**5**	**4**	**3**	2	2	1
Gomphospheria aponina KÜTZ.	1	0	0	0	0	1
Lyngbia contorta Lemm. + spec.	1	0	0	1	2	1
Merismopedia glauca + spec.	**3**	2	2	1	1	2
Oscillatoria spec.	**4**	**5**	**4**	**4**	**5**	**5**
Chlorophyceae						
Actinastrum hantzschii LAGERH.	1	2	1	**3**	**3**	**4**
Ankistrodesmus acicularis A. BRAUN	2	2	1	2	2	**3**
Ankistrodesmus falcatus (CORDA) RALFS.	**4**	**4**	**4**	**4**	**3**	**3**
Ankistrodesmus falcatus mirabilis W. & G. S. WEST	**4**	**5**	**3**	**3**	**3**	**4**
Ankistrodesmus longissimus (LEMM.) WILLE	1	1	0	1	1	1
Ankistrodesmus setigerus (SCHRÖD.) G. WEST	0	0	0	1	**3**	0
Asterococcus superbus SCHERFFEL	0	0	0	1	2	2
Characium limneticum LEMM.	**3**	**3**	**3**	**3**	**4**	2
Characium tuba HERM.	0	0	0	0	1	2
Chodatella ciliata (LAGERH.) LEMM.	0	0	0	0	2	2
Chodatella subsalsa LEMM.	1	1	0	1	0	0
Cladophora spec.	**3**	**3**	2	2	**3**	**3**
Coelastrum microporum NÄG.	**3**	**3**	**3**	2	**3**	2
Crucigenia quadrata MORREN	**3**	**3**	2	1	2	**3**
Crucigenia rectangularis (A. BR.) GAY	1	1	1	1	2	1
Crucigenia tetrapedia (KIRCHN.) W. ET G. S. WEST	1	1	1	1	2	1
Dictyosphaerium ehrenbergianum NÄG. + *pulchellum* WOOD	1	1	1	1	2	**3**
Dictyosphaerium spec.	1	1	1	1	2	0
Eudorina elegans EHRB.	1	1	1	1	0	0
Geminella spec.	2	1	2	**4**	2	1
Kirchneriella contorta (SCHMIDDLE) BOHLIN	0	1	0	1	1	0
Kirchneriella subsolitaria G. S. WEST	1	1	1	0	0	0
Kirchneriella lunaris (KIRCH.) MÖB.	**3**	2	2	1	1	1
Oocystis lacustris CHOD.	0	0	0	0	0	2
Oocystis solitaria WITTROCK	0	0	0	0	1	1

Name of the organism	1953	1954	1955	1956	1957	1958
Oocystis spec.	1	1	1	1	2	2
Oocystis in tetraden	1	1	1	1	1	2
Pandorina morum BORY	1	2	2	0	1	1
Pediastrum boryanum (TURP.) MENEGH.	2	1	1	2	2	2
Pediastrum duplex MEYEN	1	1	0	**3**	2	**4**
Pediastrum simplex (MEYEN) LEMM.	1	1	1	0	0	1
Pediastrum tetras (EHRB.) RALFS	1	0	0	0	1	0
Protococcus spec.	**4**	**4**	**4**	1	1	2
Richteriella botryoïdes (SCHMIDDLE) LEMM.	1	2	1	2	**3**	2
Scenedesmus abundans KIRCHN.	1	1	1	2	2	1
Scenedesmus acuminatus (LAGERH.) CHOD.	1	0	1	2	2	**3**
Scenedesmus arcuatus LEMM.	2	1	1	0	1	0
Scenedesmus armatus CHODAT	1	1	1	1	2	1
Scenedesmus bijugatus (TURP.) KÜTZ.	1	1	0	0	0	0
Scenedesmus bijugatus seriatus CHOD.	1	1	1	1	0	0
Scenedesmus costato-granulatus SKUJA	1	2	1	2	2	2
Scenedesmus denticulatus LAGERH.	1	0	1	1	0	1
Scenedesmus dimorphus KÜTZ.	**3**	2	**4**	**3**	**3**	2
Scenedesmus obliquus (TURP.) KÜTZ.	**3**	**4**	**3**	**4**	**4**	**5**
Scenedesmus opoliensis P. RICHT.	**3**	**3**	1	**4**	**3**	**4**
Scenedesmus quadricauda (TÜRP. BREB.	**5**	**5**	**5**	**5**	**5**	**5**
Scenedesmus quadricauda setosus KIRCHN.	1	2	0	1	2	2
Scenedesmus quadricauda WESTII	0	1	0	1	1	0
Schroederia setigera LEMMERMANN	0	0	1	0	**3**	2
Tetraedron caudatum incisum LAGERH.	0	0	0	0	2	1
Tetraedron minimum (A. BR.) HANSG.	0	0	1	0	1	1
Tetraedron muticum (A. BR.) HANSG.	1	1	1	2	2	0
Tetraedron regulare KÜTZ.	0	0	0	0	1	1
Tetrastrum staurogeniaeforme (SCHRÖD.) LEMM.	1	1	1	1	2	1
Tribonema spec.	2	**3**	**3**	**3**	2	**3**
Conjugatae						
Closterium acerosum (SCHRANK.) EHRB.	**3**	**4**	2	1	1	**3**
Closterium aciculare (TUFFE) WEST	0	1	0	1	1	**2**
Closterium gracile BREB.	0	0	0	0	0	**4**
Closterium spec.	1	1	0	0	1	0
Closterium moniliferum EHRB.	1	1	2	1	2	2
Mougeotia spec.	0	0	1	1	2	0
Bacillariales						
Achnanthes (different species)	0	0	1	1	0	0
Amphiprora paludosa W. SMITH	1	1	0	1	0	1
Amphora (different species)	**3**	**4**	1	2	**4**	2
Asterionella formosa HASSALL,	1	2	2	**4**	**3**	2
Bacillaria paradoxa GMEL.	0	0	1	1	1	0
Chaetoceras virtulae APSTEIN?	1	1	1	1	0	1
Cocconeis (different species)	2	1	**3**	2	2	0
Coscinodiscus rothii (EHR.) GRUN.	1	1	0	1	1	0
Cyclotella meneghiniana KÜTZ.	2	2	1	**3**	2	2
Cyclotella and *Stephanodiscus*	**5**	**5**	**3**	**3**	**4**	**4**

Name of the organism	1953	1954	1955	1956	1957	1958
Cymatopleura solea (Bréb.) W. Smith	0	0	0	1	0	1
Cymbella (different species)	1	0	0	1	1	1
Diatoma elongatum Aj.	1	2	2	**3**	**3**	2
Diatoma vulgare Bory	1	1	1	1	0	1
Diploneis spec.	1	0	1	1	0	0
Fragilaria crotonensis Kitten	0	0	1	1	1	1
Gomphonema (different species)	**5**	**5**	**5**	**4**	**4**	**4**
Hantzschia amphioxys (Ehrb.) Grun.	0	0	0	0	1	2
Melosira granulata (Ehrb.) Ralfs	1	1	2	**3**	**4**	**5**
Melosira varians C. A. Ag.	2	2	1	2	2	2
Navicula cuspidata Kütz.	**3**	**4**	2	1	0	1
Navicula rhynchocephala Kütz.	**4**	**5**	1	1	0	1
Navicula (different species)	**5**	**5**	**5**	**5**	**4**	**5**
Nitzschia acicularis W. Sm.	**3**	**5**	2	**3**	2	2
Nitzschia (different species)	**5**	**5**	**4**	**4**	**4**	**5**
Pinnularia spec.	**3**	**4**	2	1	1	1
Rhoicosphenia curvata (Kütz.) Grun.	1	1	1	2	1	1
Surirella ovata Kütz.	2	1	1	1	0	0
Surirella robusta Ehrb.	0	0	0	1	1	2
Synedra acus Kütz.	1	2	1	1	1	2
Synedra (different species)	2	1	2	1	1	1
Synedra ulna (Nitzsch.) Ehrb.	2	**3**	2	2	**3**	2
Tabellaria fenestrata (Lyngb.) Kütz.	0	1	1	2	1	1
Flagellata						
Chlamydomonas (different species)	2	2	**3**	**4**	**4**	**5**
Bicoeca planctonica Kisselew.	0	0	0	1	2	0
Chromulina stellata Pasch.	0	1	0	1	2	1
Chrysococcus biporus Skuja	1	1	1	**3**	**3**	**3**
Chrysococcus rufescens Klebs	1	0	1	2	0	1
Chrysococcus spec.	1	1	1	1	0	0
Euglena acus Ehrb.	**4**	**5**	**5**	**3**	0	**3**
Euglena deses E.	1	1	1	1	0	0
Euglena ehrenbergii Klebs	0	1	2	1	0	0
Euglena oxyurus Schmarda	**5**	**5**	**5**	**3**	1	**4**
Euglena proxima Dang.	1	1	2	1	1	2
Euglena clavata Skuja	0	1	0	1	1	2
Euglena (different species)	**3**	**4**	**4**	2	2	2
Euglena spiroides Lemm.	1	1	1	0	0	1
Euglena spirogyra E.	**4**	**4**	**4**	1	0	2
Euglena variabilis Klebs	**5**	**5**	**5**	**3**	2	**4**
Lepocinclis ovum (E.) Lemm.	1	1	1	1	1	1
Lepocinclis steinii Lemm. em Conr.	1	0	1	0	1	0
Lepocinclis texta (Duj.) Lemm. em Conr.	0	0	2	2	2	**3**
Phacus acuminatus Stokes	**5**	**5**	**4**	**3**	2	**4**
Phacus aenigmaticus Drez.	0	0	0	0	1	1
Phacus alatus Klebs	2	**4**	**3**	2	0	**3**
Phacus agilis Skuja	**4**	**4**	1	0	1	2
Phacus caudatus Hübner	**5**	**5**	**5**	**4**	**3**	**5**
Phacus longicauda (Ehrb.) Duj.	1	2	0	2	0	1
Phacus parvulus Klebs	**5**	**5**	**5**	**3**	2	**4**

Name of the organism	1953	1954	1955	1956	1957	1958
Phacus pleuronectes (O.F.M.) DUJ.	**4**	**5**	**4**	1	1	**4**
Phacus pyrum (EHRB.) STEIN	**4**	**4**	2	1	1	1
Pteromonas spec.	0	0	1	0	1	1
Synura uvella EHRB.	1	0	1	2	1	1
Trachelomonas abrupta SWIR. EM DEFL.	0	0	0	0	0	2
Trachelomonas hispida STEIN	**3**	**4**	**3**	1	2	2
Trachelomonas oblonga LEMM.	**3**	2	2	1	1	1
Trachelomonas volvocina EHRB.	**3**	**4**	2	1	1	**3**
Peridineae						
Peridinium spec.	0	1	1	1	0	0
Thecamoeba						
Arcella hemisphaerica + *discoides*	1	**3**	2	1	**3**	2
Difflugia spec.	0	0	0	0	1	1
Euglypha spec.	0	0	1	1	0	0
Trinema lineare + *enchelys*	1	1	2	1	1	1
Ciliates						
Ciliata cetera	**3**	**4**	**4**	**3**	**4**	**4**
Epistylis spec.	2	2	1	1	0	1
Codonella lacustris ENTZ.	1	0	0	1	1	1
Paramaecium spec.	**3**	2	2	1	0	2
Strombidium spec.	1	1	0	1	2	0
Tintinnidium fluviatilis STEIN	0	1	1	0	1	0
Vorticella spec.	**4**	**4**	**3**	**3**	**4**	**4**
Rotatoria						
Asplanchna spec.	0	1	0	1	0	1
Brachionus angularis GOSSE	1	2	2	2	**3**	**4**
Brachionus calicyflorus (PALLA)	1	2	1	2	**3**	**3**
Brachionus urceolaris O.F.M.	1	2	1	1	1	1
Diglena spec.	0	1	1	1	0	0
Filinia longiseta (EHRB.)	1	1	1	1	1	1
Keratella cochlearis GOSSE	1	1	1	2	2	2
Keratella quadrata (MÜLLER)	1	2	1	**3**	**3**	**3**
Polyarthra spec.	1	2	0	**3**	1	2
Rotaria neptunea (EHRB.)	1	1	0	0	1	1
Rotaria spec.	1	1	1	1	1	**3**
Synchaeta (different species)	1	1	2	1	1	2
Nematodae	**4**	**4**	**4**	1	2	**3**
Crustacea						
Bosmina coregoni BAIRD + *longirostris* JUR.	1	1	1	1	**3**	2
Ceriodaphnia pulchella G. O. SARS.	1	1	0	0	1	1
Cyclops spec.	1	2	1	**3**	2	2
Chydorus sphaericus (O.F.M.) BAIRD	1	2	1	1	2	**3**
Daphne longispina O.F.M. + *magna* STRAUS	2	2	**3**	**4**	2	**3**
Eurytemora spec.	1	1	0	1	1	0
Nauplii	**3**	2	**4**	**4**	**5**	**3**
Lamellibranchia larvae	0	0	1	1	1	0

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